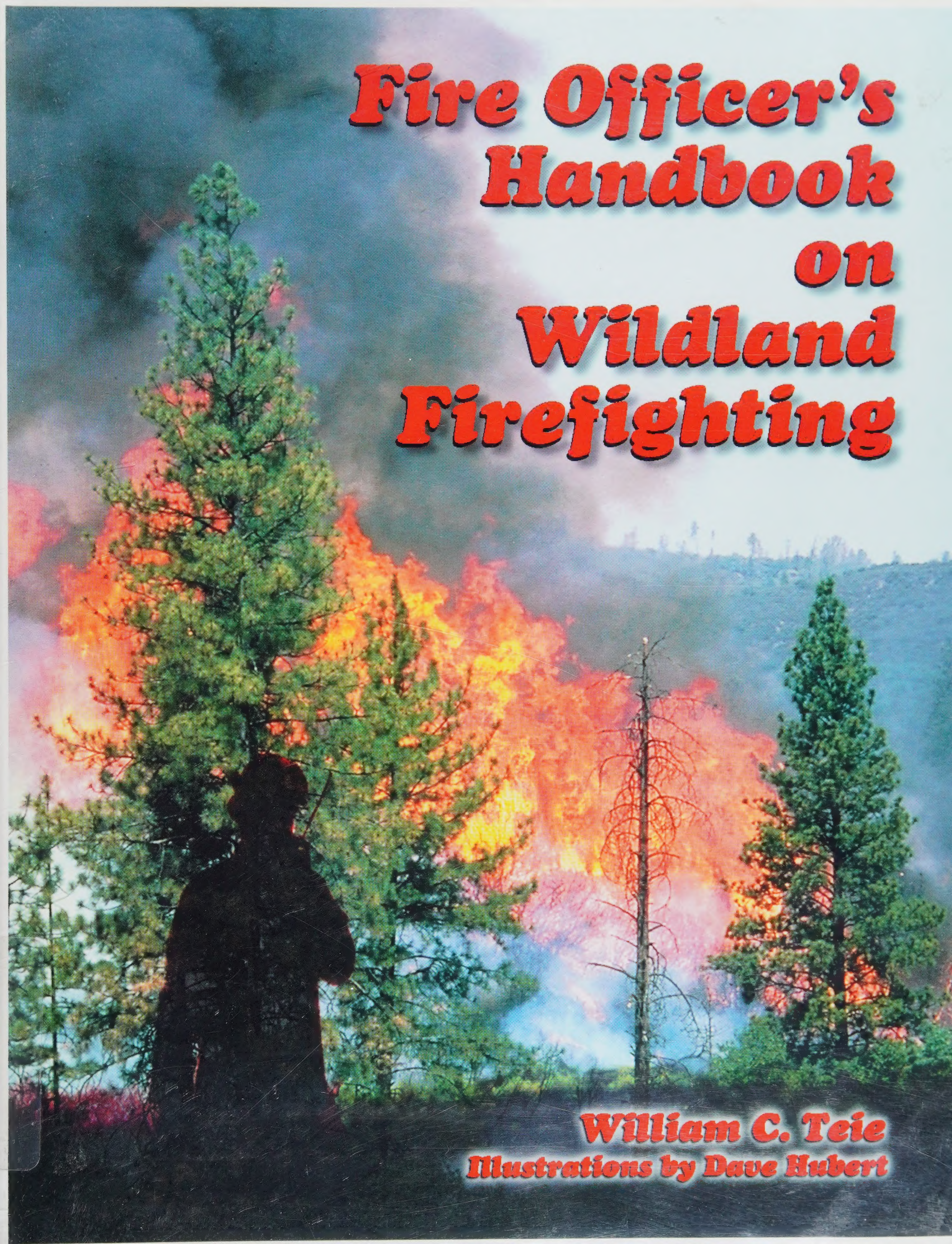
Fire Officer's Handbook on Wildland Firefighting



William C. Teie

Illustrations by Dave Hubert

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The *Firefighter's Handbook on Wildland Firefighting* was written for firefighters who needed a basic understanding of wildland firefighting. The *Fire Officer's Handbook on Wildland Firefighting* is written for the fire officer, engine captain, or battalion chief who needs a more comprehensive understanding of the subject.

The primary goal of this handbook is to attempt to explain why certain things happen in nature and on the fireground, how you can learn to predict these events by monitoring the weather and being observant, and how to apply what you learn to some realistic fire situations. However, training aids, like this handbook should be considered in the same manner as an owner's manual for a new car. It can tell you how things work, and some of the warnings signs to look for. But, it will not teach you to drive. This handbook also tells you why some things happen. It may help you to be a more knowledgeable firefighter, but it will not help you to be a better firefighter. That comes from extensive training from expert fire instructors, and actual experience on the fireground. If you want to be a successful fire officer, acquire a good technical knowledge of firefighting, and try to work with the best people you can, observing how and why they do things. The best lessons are learned by observing someone who knows what they are doing.

The text starts off with a discussion on what makes a good leader. Being a good leader is as important to being a successful fire officer as being a technically knowledgeable firefighter.

Two important "philosophical" points need to be addressed. The first is that any truly successful person needs to live by the Golden Rule. As Chief Alan Brunacini points out in his excellent book *Fire Command*, "Respect personnel—be sensitive to their needs. Forget personalities, politics and personal quirks."

And this leads us to the second point, which concerns warts. The applicable dictionary definition of a wart, for our purposes, is "an unattractiveness or smallness." It is a fact that every person and organization has warts. The problem is that most of us are not aware of our own warts, but think we need to point out the warts of our fellow man. Warts are not harmful or dangerous, but gratuitous criticism of other people's differences or shortcomings is.

It is sincerely hoped that the reader finds the book both informative and enjoyable.

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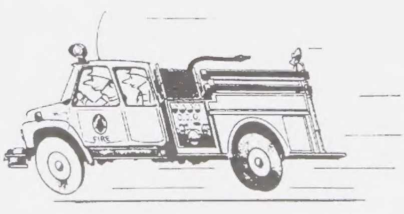

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William C. Teie

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Rescue, California, 1997

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Dedication

To my wife, Barbara, to whom I owe so much. Without her devotion and support, this handbook would not have been completed.

About the Author

William C. Teie retired from the California Department of Forestry and Fire Protection (CDF) after a successful 34-year career. He worked up through the ranks from seasonal firefighter to Deputy Director for Fire Protection. In this position, he was responsible for all of the fire protection programs within CDF.

Chief Teie was very active in the California fire service. He was on several statewide boards and committees and in 1986, was elected President of the California Fire Chiefs Association.

He is the author of the ***Firefighter's Handbook on Wildland Firefighting*** and has developed several other training and operational aids for the firefighter. He provides consulting services mainly in the area of military and space technology conversion and application to fire service use.

About the Artist

Dave Hubert retired after 30 years of service with the Orange County (CA) Fire Authority and CDF. During his career, Captain Hubert served as an engine company captain, truck company captain, in fire prevention and as a training officer. For some time, he served as the wildland fire defense coordinator specializing in community fire defense programs.

Captain Hubert was very active with the California State Firefighters Association and the Orange County Firemen's Association.

He is dedicated to his family, enjoys fire service artwork and working on his 1902 horse-drawn steam fire engine, which was featured in the 1997 Tournament of Roses Parade.

Acknowledgments

Researching and writing the *Fire Officer's Handbook on Wildland Firefighting* was one of the most intensive projects I have ever undertaken. Writing a technical book of this magnitude involves the support and assistance of many dedicated people.

The handbook has been "in the works" for close to three years. It all started with a series of interviews with scores of highly skilled wildland firefighters from throughout the western United States. These interviews were conducted in an effort to document some of their vast knowledge and expertise. It is impossible to name each participant individually. However, the practical knowledge and experience of these "hands on" experts added a very important dimension to the book. Thank you all for your generosity.

There are two people who have been most supportive in the development of this extensive document. The first and most important is my wife, Barbara. Her support and willingness to edit my "gibberish" made it possible to carry on for the 3 years of this challenging project. As with the *Firefighter's Handbook*, the quality of the artwork cannot be overstated. Dave Hubert has again done a superb job of bringing a lighthearted perspective to this otherwise inherently serious subject. Thank you also to Mark Hubert who helped his dad with the cartoon concepts.

Three other close friends must be acknowledged for their contributions to this work. Brian Weatherford, a good friend and talented chief fire officer with the California Department of Forestry and Fire Protection, once again provided support as a technical editor, reviewing the various drafts to ensure that they made sense from a technical point of view. Tim Murphy, the Chief of Fire Operations for Montana DNRC, reviewed the work to ensure that there was more than just a California perspective. And John Hawkins, a firefighter's fire manager, for his moral support and for allowing me the opportunity to spend many hours discussing the art of wildland firefighting. I should also thank my brother John, for providing research material and historic documents. He is the historian of the family—some would call him a "collector" of things.

While the interview process was underway, a concerted effort was made to gather as much up to-date material on the subject of wildland firefighting as possible. The majority of the material was developed and distributed under the authority of the National Wildfire Coordinating Group (NWCG). That material was invaluable in the development and illustration of this handbook. Most of the photographs used to illustrate the book were drawn from the thousands of slides that support the various training documents developed by NWCG. So special thanks must go to the hundreds of photographers who contributed to the development of this collection and to the people who developed the various lesson plans and program texts. The photographers for several of the pictures taken of Miller's Reach Fire #2 in Alaska could be identified and I'd like to thank them. They are Phil Bryant, Tom Dean and Gary McGeorge, all employees of the Alaska Division of Forestry.

There is another group of people who must be acknowledged. They are the people who "fought" the fires found in Chapter 11. They were asked to review the situations and present their best plan for dealing with them. They are: Tom Doyle, Kevin Efroymson, Rick Grady, Paul Hunter, Eric Kurtz, Joe Lowe, Ray Lundby, Gordon Martin, Diana Martin, Todd Miller, Mike Moore, John Pilsworth, Bob Sandman, Bruce Suenram, Kirk Summers, Tom Tarp, Terry Vaughn, and Doug Williams.

Four other people who aided in the development of the work were Jill Meryl Levy of Firebelle Productions, a firefighter in her own right, who edited the work to ensure there were not too many violations of the English language, Diane Januszak, who provided the final polish with her proofreading skills and Gil Caravantes and Dan Powell of Commerce Printing Services who provided vital technical support.

Again, as I did in the *Firefighter's Handbook on Wildland Firefighting*, I must thank the men and women of the California Department of Forestry and Fire Protection, from whom I learned so much. And finally, I'd like to thank all of those people who asked, "When will you have the fire officer's book done?" They have provided the continuing incentive to carry on, when the brain went blank.

W.C.T.

Foreword

At one time it was very difficult to transfer knowledge that had been obtained from one generation to another. Before the development of the printed word this process consisted of oral tradition, where the older generation would pass information down to the younger through a process of mentoring. You would have thought that with the invention of the printed page that this would have eliminated the need to have a personal method of assuring the passing of knowledge. It hasn't.

There is still a need for each generation to compile and distribute the knowledge of the past generations in order for there to be an orderly transfer of wisdom to the next in line. Today, we call that teaching. One of the most important tools of the teacher is the textbook. Yes, even today, in the era of electronic technology we still have a need for the textbook to serve as a guide for the development of knowledge in students.

Chief Bill Teie has written a textbook that is as close as you can get to mentoring and is an extremely useful tool for teaching. He has prepared a text for the fire officer that combines his personal experience, the experience of other highly skilled professionals, with the width and breadth of knowledge that is needed for effective performance on the fire ground. The book contains a unique combination of wit, wisdom and workable methods for you to utilize.

As an instructor myself, I appreciate a text that flows with the topic and contains examples from the real world, instead of the hypothetical. This text contains both. It is a reflection of Chief Teie's commitment to excellence in the fire profession as well as a memorial to those individual firefighters that paid the price through experience to give us the lessons that we need to learn.

As a fire officer, I feel that Chief Teie's contributions to the knowledge base of the fire service are very significant. This is not a text that should be purchased and set on a shelf. Its a work that deserves review on a frequent basis. Even the most experienced fire officers can benefit from this work, especially those that are now becoming involved in the rapidly expanding role of the urban wildland interface fire, or those that must serve on mutual aid companies in catastrophic events.

Lastly, as a writer I applaud Chief Teie for the visual quality of this text. He has been most diligent in giving the reader not only a relevant document, but also one that is enjoyable to read. His use of illustrations and key points makes this text one that I can almost hear being quoted on the fire ground itself.

My congratulations for a job well done and a book that serves us well.

Ronny J. Coleman, Chief
California State Fire Marshal
Chief Deputy Director
California Department of Forestry
and Fire Protection

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Introduction

There is no question that wildland firefighting has become more complicated. In the past, firefighters could generally choose when and where they were going to fight a fire. Now, with the presence of millions of structures in our wildlands, priorities have changed drastically.

In the past, all fires were fought aggressively because they were "bad" for the forests. Now we know that fire is a vital ingredient to a healthy forest. In the past, we cut all snags because they could contribute to spotting. Now we attempt to salvage snags, because they may be vital to the preservation of a species of animals.

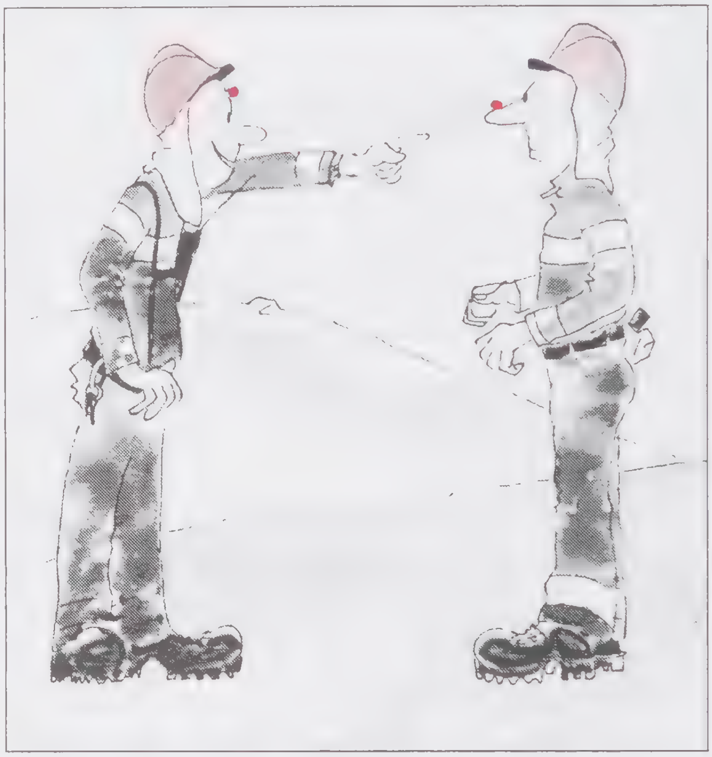
Fortunately, the Art and Science of firefighting has been keeping pace with these developments. Studies are constantly considering ways to make firefighting safer and more effective. In the last twenty years we have seen the development of wildland protective clothing, fire shelters, and Class A foam. We are up to 18 "Watch Outs," and studies are underway to determine how to minimize the deterioration of rational thinking and decision-making under severe stress and fear.

The *Firefighter's Handbook on Wildland Firefighting* was written for firefighters who needed a basic understanding of wildland firefighting. The *Fire Officer's Handbook on Wildland Firefighting* is written for the fire officer, engine captain, or battalion chief who needs a more comprehensive understanding of the subject.

The primary goal of this handbook is to attempt to explain why certain things happen in nature and on the fireground, how you can learn to predict these events by monitoring the weather and being observant, and how to apply what you learn to some realistic fire situations. However, training aids, like this handbook should be considered in the same manner as an owner's manual for a new car. It can tell you how things work, and some of the warnings signs to look for. But, it will not teach you to drive. This handbook also tells you why some things happen. It may help you to be a more knowledgeable firefighter, but it will not help you to be a better firefighter. That comes from extensive training from expert fire instructors, and actual experience on the fireground. If you want to be a successful fire officer, aquire a good technical knowledge of firefighting, and try to work with the best people you can, observing how and why they do things. The best lessons are learned by observing someone who knows what they are doing.

The text starts off with a discussion on what makes a good leader. Being a good leader is as important to being a successful fire officer as being a technically knowledgeable firefighter.

Two important "philosophical" points need to be addressed. The first is that any truly successful person needs to live by the Golden Rule. As Chief Alan Brunacini points out in his excellent book *Fire Command*, "Respect personnel –be sensitive to their needs. Forget personalities, politics and personal quirks."



And this leads us to the second point, which concerns warts. The applicable dictionary definition of a wart, for our purposes, is "an unattractiveness or smallness." It is a fact that every person and organization has warts. The problem is that most of us are not aware of our own warts, but think we need to point out the warts of our fellow man. (The fire officer on the right has a clear view of the wart on his fellow officer's nose, and doesn't hesitate to point it out. But he seems to be unaware of the wart on his forehead.)

Warts are not harmful or dangerous, but gratuitous criticism of other people's differences or shortcomings is.

Two technical clarifications need to be made. All temperatures in the book are degrees, Fahrenheit. You also see reference to chains as a measurement of length. A chain is a historical engineering measurement. A chain equals 66 feet and there are 80 chains in a mile. An acre is ten square chains.

For those of you who are interested, the handbook was written in Microsoft Word 6.0a, and published in Pagemaker 6.0. The graphics were drawn in CoralDraw 4.0 or Photoshop 3.05. All of Dave Hubert's art was scanned using a Hewlett Packard Scanjet IIcx scanner. All of the camera-ready copy was printed using a Hewlett Packard Laserjet 4m printer. The text, graphics and art in various formats (tiff, eps, psd, etc.) constitute over 1 gigabyte of disk space. A bunch when it comes to backing it up!

In closing, the reader should keep the following in mind when reading this book. The material in this handbook is intended to be an informational and pictorial presentation of some of the issues involved in wildland firefighting. It is not intended to be used in lieu of the rules and regulations of the reader's department or other applicable authorities. The application of any of the recommendations should be modified, as appropriate, by particular circumstances and your own best judgment.

1

Leadership

"Which way did they go? How many were there? How fast were they going? I must find them, for I am their leader!"

In this chapter, you'll

- *Learn that your primary responsibility is ensuring safety.*
- *Learn some of the traits and characteristics of successful leaders.*
- *Learn general leadership skills (e.g., delegation, conducting meetings, etc.).*
- *Learn how to be a good listener.*
- *Learn how to counsel and discipline.*
- *Learn how to manage conflict.*
- *Learn the process of decisionmaking.*
- *Learn how to avoid counterproductive (and possibly dangerous) decisions.*
- *Learn how to minimize the collapse of decision making under stress.*

Most of this handbook is dedicated to the technical aspects of suppressing wildland fires. However, the fire officer who is responsible for supervising fire suppression personnel **must first of all be a good leader**. Knowledge and ability in firefighting techniques will not compensate for a lack of leadership skills. In fact, a fire officer who has only the general skills and knowledge of fire suppression but is a good leader will get more done on the fireline than a highly skilled firefighter who doesn't know how to lead. You may have been given the rank and authority, but to fulfill your responsibilities successfully and with credibility, you must learn and practice good leadership skills.

Attributes of a Leader

As a fire officer, you have been appointed to supervise a group of individuals. As noted above, this doesn't automatically make you a leader. **Leaders are not appointed, they are selected by those who desire to be led** (Figure 1.1). Thus, leadership may be seen as a cooperative relationship between those who choose to lead and those who agree to follow. To quote Warren Bennis and Burt Nanus in their book *Leaders, The Strategies for Taking Charge,* the five key skills of a leader are:

Leaders are selected by those who want to be led.

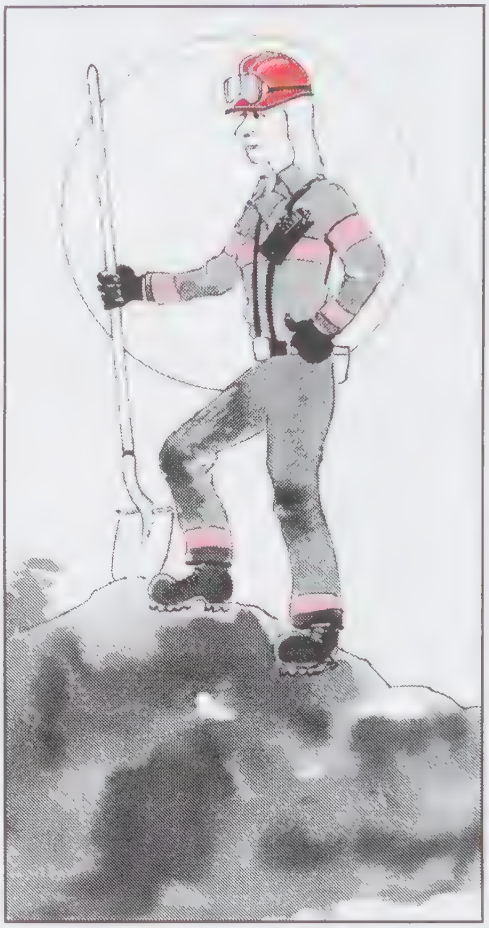


Figure 1.1 Leaders are not appointed, they are selected by those who desire to be led.

Accept people as they are.

- The ability to accept people as they are, not as you would like them to be. In a way, this can be seen as the height of wisdom—to 'enter the skin' of someone else, to understand what other people are like on their terms, rather than judging them.

Deal with issues in the present, not the past.

- The capacity to approach relationships and problems in terms of the present rather than the past. Certainly it is true that we can learn from past mistakes. But using the present as a takeoff point for trying to make fewer mistakes seemed to be more productive for our leaders—and certainly was more psychologically sound than rehashing things that are over.
- The ability to treat those who are close to you with the same courteous attention that you extend to strangers and casual acquaintances. The need for this skill is often the most obvious—and lacking—in our relationships with our own families. But it is equally important at work. We tend to take for granted those to whom we are closest. Often we get so accustomed to seeing them and hearing from them that we lose our ability to listen to what they are really saying or

to appreciate the quality—good or bad—of what they are doing. Personal feelings of friendship or hostility or simple indifference interfere. There are two aspects to this problem of over-familiarity. The first is that of not hearing what is being said: selective deafness leads to misunderstandings, misconceptions and mistakes. The second is the matter of the feedback we fail to provide, to indicate our attentiveness.

Treat friends and strangers in the same way.

- The ability to trust others, even if the risk seems great. A withholding of trust is often necessary for self-protection. But the price is too high if it means always being on guard, constantly suspicious of others. Even an overdose of trust that at times involves the risk of being deceived or disappointed is wiser, in the long run, than taking it for granted that most people are incompetent or insincere.
- The ability to do without constant approval and recognition from others. Particularly in a work situation, the need for constant approval can be harmful and counterproductive. It should not really matter how many people like leaders. The important thing is the quality of work that results from collaborating with them. The emotionally wise leader realizes that this quality will suffer when undue emphasis is placed on being a 'good guy.' More importantly, it is a large part of the leader's job to take risks. And risks, by their very nature, cannot be pleasing to everyone.

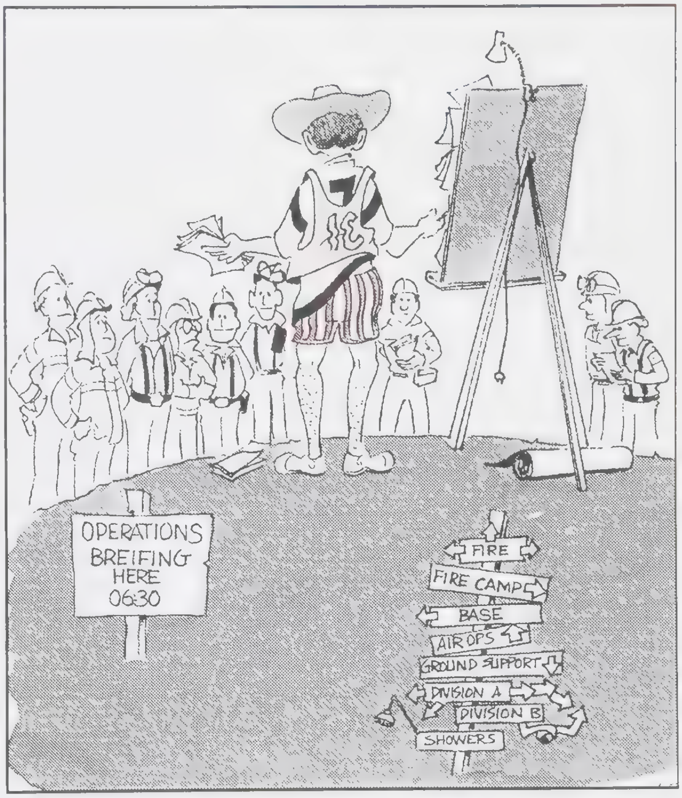


Figure 1.2 You set the standard by what you do. If you don't wear all of your safety gear, you imply to others that they don't have to wear safety gear. Don't be a person who lives by the motto, "Do as I say, not as I do!"

Another attribute of good leaders is that they set the standard for their people. What you "do" is the most important factor in demonstrating to others what is acceptable––and unacceptable—behavior in your organization. If you don't wear all of your safety gear, you are tacitly communicating that it is okay not to wear safety gear. If you are in poor physical condition, you are implying that it's okay to be in poor physical condition (Figure 1.2).

What you do is more important than what you say.

Now you know some of the interpersonal skills which are important for a good leader to acquire and practice. What do those who desire to be led expect from their leaders? In the book *Credibility: How Leaders Gain and Lose It, Why People Demand It,* the authors discuss a survey of more than 15,000 people who were asked what they thought was the key to effective leadership. Which of the following traits or characteristics do you think were selected as most important: being fair-minded, being cooperative, being honest, or being imaginative?

Honesty is one of the most important characteristics of a leader.

From a list of 20 traits, honesty was selected as most important by a significant majority of respondents. In fact, the top four characteristics of admired leaders, and the percentage of people who selected them, were as follows:

Being **honest**.	87 percent
Being **forward-looking**.	71 percent
Being **inspirational**.	68 percent
Being **competent**.	58 percent

Interestingly, the results were the same when the respondents were asked to rate the most valued traits of their peers. Honest people have credibility—and that's what earns leaders the trust and confidence of their people. High credibility leaders foster such things as greater pride in the organization, a spirit of cooperation and teamwork, and feelings of ownership and personal responsibility.

Credible leaders keep their promises and commitments.

Some of the other characteristics of credible leaders are:

- They do what they say they will do. They keep their promises and follow through on their commitments.
- Their actions are consistent with the wishes of the people they lead. They have a clear idea of what others value and what they can do.
- They believe in the inherent self-worth of others. And they learn how to discover and communicate the shared values and visions that can form a common ground on which all can stand.
- They are capable of making a difference in the lives of others—and liberating the leader in everyone.
- They admit their mistakes. They realize that not accepting responsibility for mistakes is damaging and erodes credibil-

ity. However, when they admit to a mistake, and do something about it, they maintain trust and credibility.
- They arouse optimistic feelings and encourage their people to maintain positive thoughts about the possibility of success.
- They create a climate for learning characterized by trust, openness, and enthusiasm.

You have to believe in yourself.

It isn't easy to be a good leader. However, you probably already possess many of the traits discussed above. The real challenge is to consistently practice these skills and principles when the going gets tough.

Create a climate for learning.

Leadership Styles

There are five general leadership styles:

Telling - The "telling" leader says, **"This is how it is to be done."** This style of leadership can be very tiring for both the leader and those being led. Telling leaders maintain very tight control, stifling the growth of their people and creating unnecessary frustration for themselves. This style may occasionally be appropriate with an inexperienced group or with people who have never worked together before. However, "telling" leaders are usually high on task accomplishment and low in communication and interpersonal skills. These leaders do not want feedback. They are not much fun to work for.

Are you a "teller," "seller," "consultant," "joiner," or "dictator?"

Selling - The "selling" leader is one who tells people, **"Here is how to do it and why."** This can be used with a group who have a general knowledge of the task at hand and have worked together before. The selling leader's style is also high on task accomplishment and low on two-way communications. Again, not a lot of feedback is desired. These leaders must convince people that they know what they are talking about. This style is often used to sell policy from high levels in the organization. If the followers do not trust the leader, this style will not work.

Consulting - The "consulting" style leader says, **"We'll work this out together."** A leader who uses this style of leadership has to have a high level of confidence in the group. The group has to have a moderate level of maturity and experience, and must be familiar with the task. These leaders ask for and receive input. They demonstrate that the input is valuable by using it, as appropriate. These leaders still retain the ultimate authority and responsibility for how the task will be handled. This model best meets the needs of today's fire service. It is also the model that best fits with the Incident Command System and its requirement for feedback from all levels.

A consulting leader involves subordinates.

Joining - The motto of the "joining" leader is, **"It is up to the group to handle the task."** This style of leadership is possible only when there is a high level of group maturity and knowledge. In addition, the group should have worked together before, and have a high level of mutual trust. This group must know each others' strengths and weaknesses. In this style of leadership, the task must be well-defined and clearly understood. The group must know the limits or boundaries of its authority and responsibility. Finally, they must have time to develop a group decision.

Dictatorial - This style of leadership doesn't really need defining. Fortunately, this style is out, hopefully permanently. Some of the more famous leaders who used this style were Attila the Hun, Hitler, Stalin, and currently, Saddam Hussein. This is not a form of leadership that is compatible with a democracy or today's management philosophies. But, it was not that many years ago that the fire chief, district ranger, etc., had dictatorial authority, including the hiring and firing of people who did not "toe the mark." Some old timers could tell you some real tales about these "leaders."

Dictators have no place in the fire service.

As you can see, a group's maturity and experience working together should help determine the leader's style. You can't use the "joining" style with an inexperienced group; they will become confused. If you use a "telling" style with a very experienced group, you will probably alienate people. In addition, various leadership styles may be used throughout an operation. For instance, the Incident Commander may use a consulting style with the Command and General Staff, while a Division/Group Supervisor may use a "joining" style with a highly experienced group.

Several external forces may play a part in the selection of leadership style. If the task at hand is an emergency, the style used will probably differ from that of a routine task. As noted above, the group's level of experience and familiarity help determine leadership style. The leader's personal strengths, weaknesses, and preferences will play the greatest role in determining which style is selected. You should select the model that will provide the most effective results and that best balances the task at hand with the skill and capabilities of all those involved.

You may have to modify your style to match the situation.

Delegation of Authority

Leadership is the process of getting others to assist in achieving a common goal. If the goal, whether suppressing a fire or holding a conference, is more than one person can handle, then the assistance of subordinates will be needed.

In order to be an effective leader, you have to learn to delegate successfully. Delegation means that a supervisor gives the authority, responsibility, and accountability for completing a job or task to a subordinate. The subordinate must have the skills and resources to complete the task. And the leader must have the confidence not to interfere unless absolutely necessary. Delegation is a good way to allow others to develop ownership in the goal and tasks at hand (Figure 1.3).

If you don't know how to delegate, you will be a busy fire officer.

The three parts to delegation are:

- **Authority** - This is the conferred power to make decisions and take actions to accomplish a task. A supervisor should define the limits of the authority that a subordinate may use in accomplishing the task.
- **Responsibility** - Once subordinates accept responsibility for a task, they have the moral and legal obligation to make decisions and take actions to accomplish that goal. The amount of authority conferred must match the degree of responsibility. It is unfair to give subordinates responsibility for a task without giving them the authority and resources to get it done. Keep in mind, however, that the supervisor always retains the ultimate responsibility for the accomplishment of a task.
- **Accountability** - If subordinates are given the authority and responsibility, then they should be held accountable for accomplishing the assigned task. However, as noted above, the ultimate responsibility for the task remains with the supervisor, who should ensure that the subordinates are in fact getting the job done.

You have to define the limits of authority when delegating tasks.

If you give a person the responsibility for a task, they must have the authority to get it done.

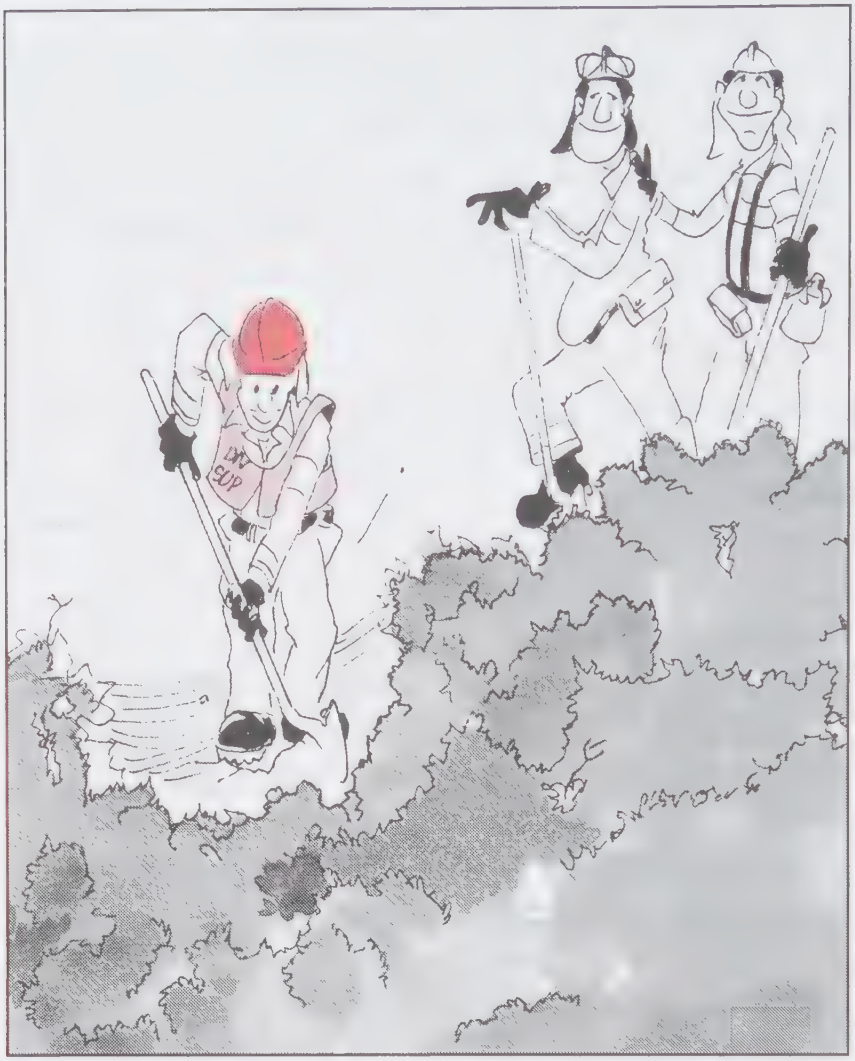


Figure 1.3 This fire officer hasn't learned to delegate —he does all the work himself while the troops stand by and watch.

Delegation is giving subordinates the authority, responsibility, and accountability to complete a task.

The supervisor always retains ultimate responsibility for a task.

You should routinely delegate tasks for which you don't have enough time. If you have a task that you have been unsuccessfully wrestling with for some time, ask someone else with a fresh approach to take a stab at it. Don't just delegate the undesirable jobs; give your people missions that provide an opportunity for them to learn and "shine." Don't delegate away your responsibility (by definition you can't), confidential or private assignments, or extremely high-risk jobs. Those you must accomplish yourself.

When selecting a person who will be given the authority, responsibility, and accountability for accomplishing a task, you need to ensure that the person is competent, credible, and self-confident. If you select a person who doesn't have these traits, you are setting them up for failure and the task will not be completed. Select the right person to do the job.

However, delegation is not just a process for getting tasks accomplished through others. It can be a learning process by which subordinates can increase their abilities. It is also a way to add depth to an organization. Most importantly, perhaps, delegation is a way to build group ownership in the organization and to fashion a team with common goals.

Make sure the subordinate has the capacity to accomplish the task.

There are several steps to delegation. They are:

- **Define the task** - You have to tell subordinates what you want done, the details and parameters of the task, any deadlines, and whether they may draw upon others for assistance. You should also ensure that they have the necessary knowledge, training, tools, and equipment. Note that you do not tell subordinates **how** you want the job done. That should be up to them to determine. In some cases, the delegated authority is put in writing. This is especially true when the task is complicated or goes beyond normal delegation, such as when an agency manager gives authority to an Incident Commander to suppress a fire.
- **Get agreement on what is to be done** - Don't force acceptance of the mission. Whenever possible, give subordinates permission to reject a task (presumably for a valid reason). Ask for feedback regarding any changes in the assignment that would make it more acceptable or attainable. The key is that the subordinate willingly accepts the assignment.

Delegation can enhance learning.

- **Accountability** - Establish a way to track progress. This may be in the form of written milestones or objectives. The comprehensiveness of the tracking process is dictated by the complexity or importance of the task and the capabilities of your subordinates. It should be clear that the final results will be evaluated.
- **Be available** - A supervisor should always be available to offer input and assistance if necessary. However, delegation will not work if you don't allow employees to do the job as independently as possible. Remember, you gave them the authority and responsibility to do the job; now let them. This doesn't mean you can't provide constructive feedback or correct deficiencies. In fact, if safety issues are involved, you have a duty and obligation to intervene.

Tell them what you want done, not how you want it done.

- **Reward accomplishments** - Rewards shouldn't be held until the task is completely accomplished. Provide positive feedback and praise along the way. This reinforces a positive relationship between the supervisor and subordinates, and creates enthusiasm for successful completion of the task. Be sure to reward subordinates if the completed task meets established expectations. All rewards and positive feedback should be appropriate and sincere.

Be available to assist.

There may be times when a supervisor gets a task returned without it being completed. This is called "reverse delegation." If this happens, give the task back and explain to your subordinates why the task is incomplete. Provide any help and support that may be needed, but make it clear that you expect them to complete the task and that you aren't going to do the job for them.

Listening

It is likely that the topic of listening is deserving of a whole chapter (or book) rather than a few paragraphs. Not only is listening critical to good leadership, it is important to virtually every aspect of a fire operation (Figure 1.4).

Rewards and positive feedback should be sincere.

Exceptional listening skills have been identified as one of the common characteristics of credible leaders. A willingness to listen carefully to subordinates and, if necessary, to hear the "bad news," keeps leaders from becoming isolated from critical information and feedback. If you are able to get information from the various levels and functions of the organization, you will be better able to make sound decisions.

Careful listening to *all communications* at an incident is essential to life safety as well as the success of your operations. For the purpose of this chapter, however, we will concentrate on the importance of good listening skills to credible, successful leadership.

There are five states of listening:

The ability to listen is critical to a fire officer.

- **Ignoring** - This is when you simply ignore other people and do not listen to them at all. You may have something else on your mind, or perhaps you just aren't interested in what is being said.
- **Pretending** - This is when you nod okay, or say "Yeah, Uh-huh, Right." Again, you may appear to be listening, but your brain is occupied with other things.
- **Selective listening** - In this state of listening, you only hear selective phrases or words. As a child, you probably heard anything that centered on candy or toys. As an adult, you

may hear things that personally interest you. However, everything else is tuned out.

- **Attentive listening** - During this state of listening you actually "tune in" and actively listen to what is being said. You pay attention and focus on the words.
- **Empathic listening** - This is the highest state of listening. In this state, you listen with the intent of learning and of understanding the other person. You are not only focused on the words that are being said, you also "listen" with your eyes, observe body language, and try to sense the emotions behind the words.

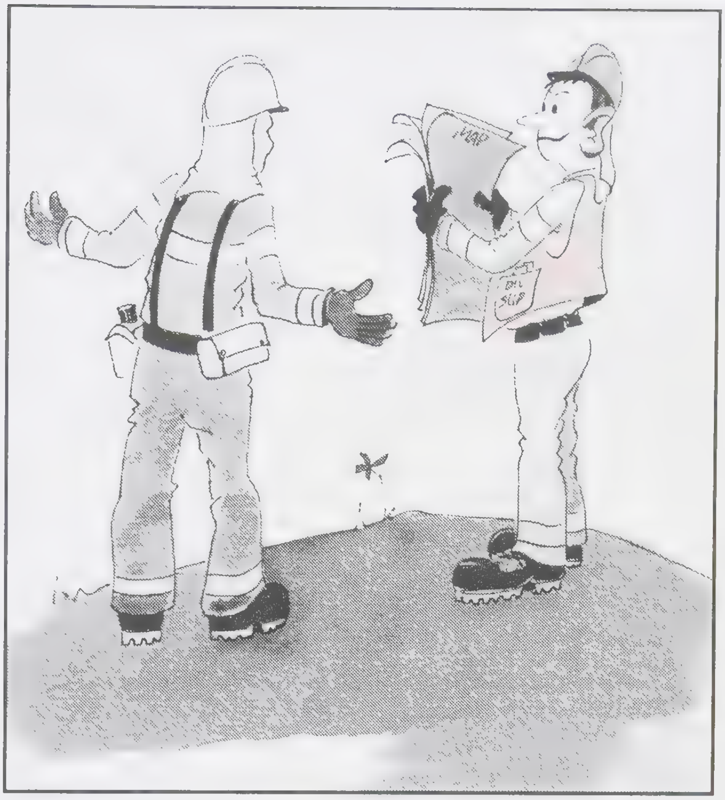


Figure 1.4 This fire officer is a good listener. (Big ears are optional.)

Good listeners get out from behind their desks and go to where the employees are. They try to establish a "setting" that encourages communication. They provide meaningful feedback. And they act on what they hear. People will stop communicating their ideas or problems if everything seems to end up in your mental "round file."

If you are going to be a successful fire officer, you have to listen and learn from those around you. This is the primary way you gain intelligence on an emergency incident and learn the various solutions to day-to-day problems. Listening is about learning and trust. Trusting other people encourages them to trust and to openly communicate with you.

There are many forms of listening.

Organizational Structure

As a fire officer, you must know and understand the organizational structure in which you work. This understanding should not be limited to just those above and below you, but of the whole department. It shouldn't even stop with your own organization; be familiar with the structure of other federal, state, and local organizations.

To start any study of an organization, begin with its organization chart. This will give you a two-dimensional view of how the department is organized. It will show you who is on top, or in charge, and how responsibility is delegated. There are three main types of organizational schemes within most fire departments: the formal organization that is identified by boxes, titles and lines; the informal organization for which there is no chart, but by which most of the work gets done; and finally, the organization used to manage emergencies. All of them are different!

Listening is about learning and trust.

The Chain of Command

More than one fire chief, fire management officer, or fire officer has been overly constrained by the chain of command (Figure 1.5). This shouldn't happen but will, if you don't take the time to study the command structure in your organization.

The chain of command is nothing more than the linking of responsibilities and relationships. Each box on the organization chart is linked with boxes above and below it. The lines between the boxes are the "chain" or link between various positions. The placement of the boxes also represents supervisory relationships.

There are three organizational schemes: formal, informal, and incident command.

Some feel that the chain of command is "all powerful and sacred," and that all information, communications, orders, food, and water must flow down the chain of command. And "God help

Don't let the chain of command get you down.

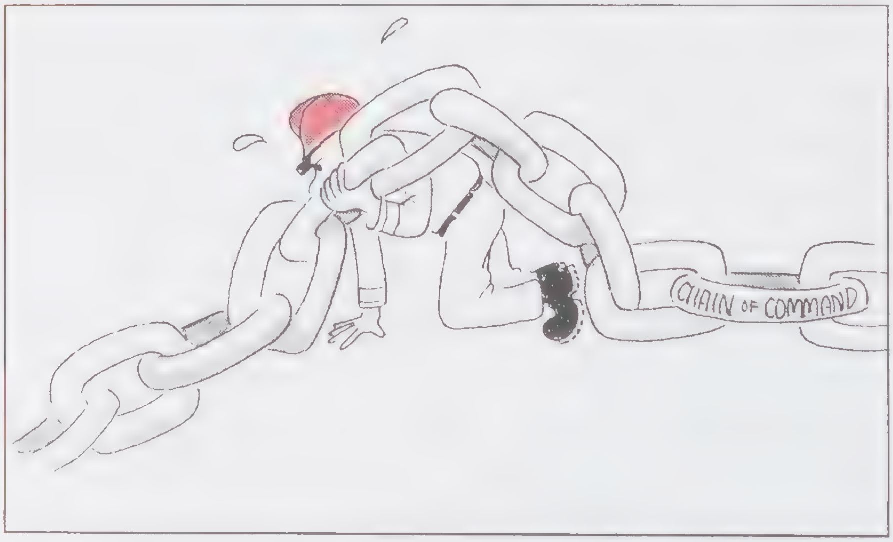


Figure 1.5 This fire officer is being overly constrained by the chain of command.

you" if you violate the chain of command going up. This philosophy should have no place in your thinking. Policy development should flow through the chain of command, but routine information doesn't have to follow that route. Some people forget that the lines go in both directions, as should information, communications, and responsibility (Figure 1.6).

The Informal Organization

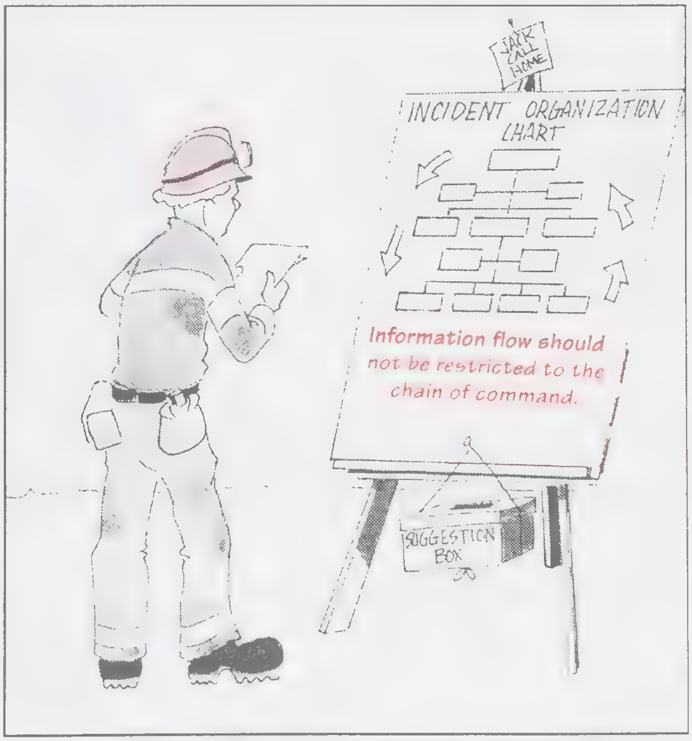
The informal organization can be very powerful.

The informal organization "exists" outside the formal organizational structure; sometimes it is much more effective. The informal organization consists of the networking of old friends, associates, or colleagues who regularly discuss events and organizational direction. The leaders of such a group are not identified by boxes on a chart, but rather by whose agenda is most often followed.

The Emergency Operation Organization

Organizational structures on emergencies vary from agency to agency and from Incident Commander to Incident Commander. Even when a formal organizational scheme like the Incident Command System or Fire Ground Command are used, they often differ in some respects.

Whatever system your organization uses, learn what it is and use it at all times. The middle of a firefight is not the time to change command structures, so ensure that whatever system is used, is used consistently by you and all employees. Mutual aid and multi-jurisdictional incidents led to the development of the Incident Command System (ICS) and MultiAgency Coordination (MAC) structure. It is important that you understand these command structures. (They will be discussed in some detail in Chapter 7.)



Information flow should not be restricted to the chain of command.

Figure 1.6 Organization charts depict the chain of command, not necessarily the flow of information.

Strategic or Tactical Thinking

The middle of a firefight is not the time to switch organizational structures.

As a firefighter, you normally function in the tactical mode. You squirt water on the fire; you perform CPR; you set backfires. These are all tactical events. When you become a fire officer, you must begin to think strategically. This means that you have to think beyond the tactics and widen your focus (Figure 1.7).

Sometimes fire officers don't recognize the difference between tactical and strategic goals. They should be thinking "future" but are thinking "right now." For example, when you

Fire officers have to think strategically.

Overwhelming a fire with firefighting resources may be effective, but it isn't very efficient.

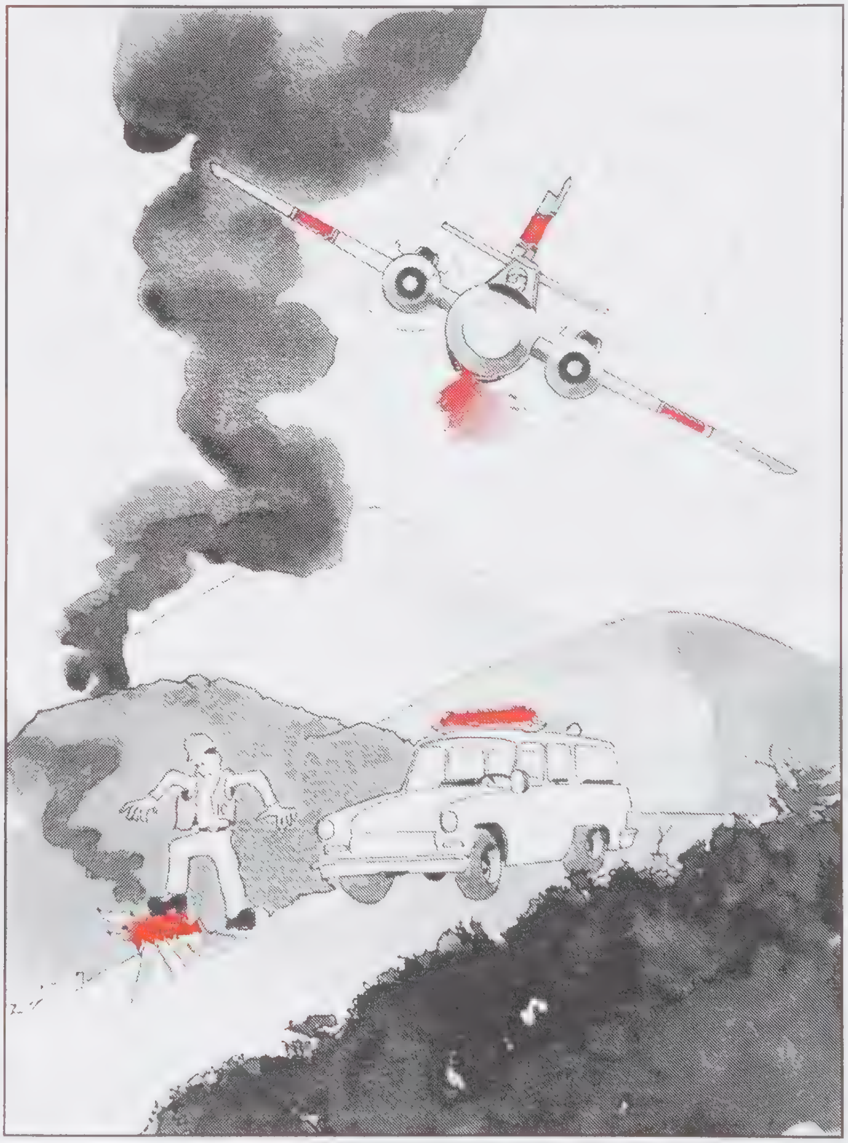


Figure 1.7 This fire officer is in a "tactical mode," concentrating on the task at hand and not aware of other problems he should be dealing with.

order equipment and personnel, be sure you are ordering them for the situation as it will be when they arrive, not as it exists now. Predict what the fire will do and what it will take to suppress it in the future. Consider the time it will take to get the appropriate forces in place and ready to fight fire. Now you are thinking strategically. Remember, everything will take longer than you think, whether it's getting additional resources or constructing a piece of fireline.

Too many Incident Commanders never get out of the "initial attack" mode of operation.

At times it appears that the Incident Commander's strategy is to overwhelm the fire by continuing to order and receive resources until the fire goes out. It is sometimes said that "the more engines you send to a fire, the larger the fire will get." This is the result of failing to develop a realistic strategy, objectives, and an appropriate plan. This approach deprives others of needed resources, and unnecessarily drives up the cost of fighting the fire (Figure 1.8).

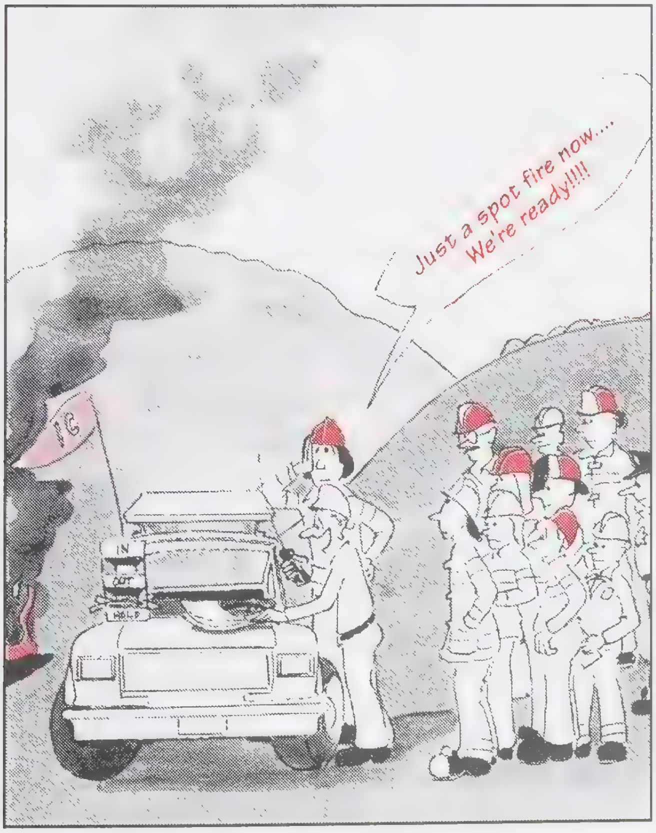

Just a spot fire now.... We're ready!!!!
IC
IN
OUT
HOLD

Figure 1.8 This fire officer believes in the strategy of "overwhelming" a fire. This deprives others of needed resources, and drives up the cost of fighting the fire.

Another sign that a fire is not being managed by strategic thinkers is when all actions are reactionary. The fire flares up during the afternoon, and the base camp is emptied of resources that are trying to rest. Each

An Incident Commander has to look at the larger picture.

Have you ever been on a fire that has been "initial attacked" to death?

As a fire officer you will have to see both the forest AND the trees.

Resting the brain is critical. A 15-minute break can do wonders.

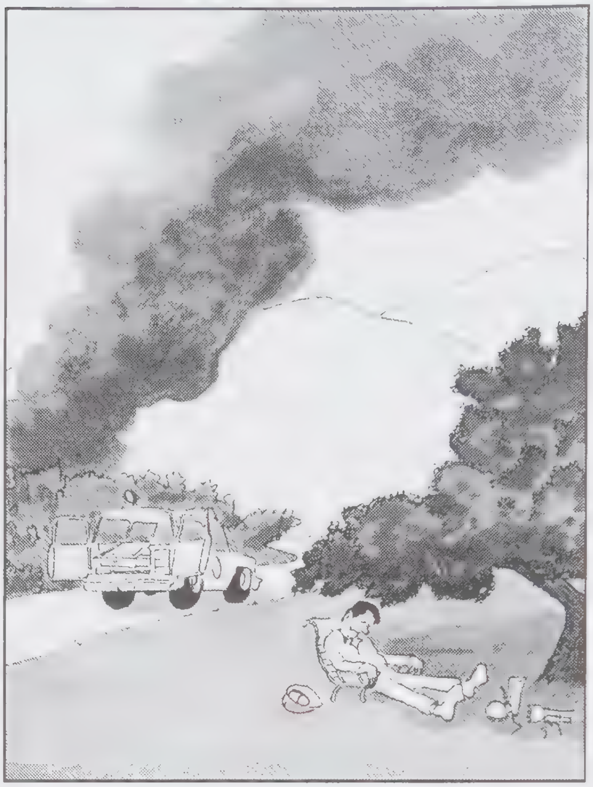


Figure 1.9 This fire officer is taking a break from the "chaos" of the fire fight. With as little as a 15-minute break from the action, your head will clear and you will be much more effective.

flare-up is handled like a new fire, because the Incident Commander is still thinking "initial attack phase" rather than managing the big picture. This is a very ineffective and inefficient way to fight fire.

We have all heard the saying, "there are times when you can't see the forest for the trees." As a fire officer, you must be able to step back and take a broader and more global view of things. Although this can be very difficult to do, especially in an emergency, you have to observe the whole "forest," not just the individual "trees" in your immediate vicinity.

If things really start to overwhelm you, you should take a break from the incident and allow your thinking to clear. One approach to getting a little "down time" is to tell people that you will be off the air for a while. Then turn down the radio, and face away from the fire. Think about fishing, sporting events, the family, anything but the fire. You will be amazed how much just a 15-minute mental break will improve your ability to think effectively again. Now turn the radio back on and proceed (Figure 1.9).

The Abilene Paradox

The book *The Abilene Paradox,* by Jerry Harvey, offers some interesting insights into how a group may go along with a decision that the individual members do not agree with. In *The Abilene Paradox* an organization or group of individuals take an action contrary to the real desires of the group. Two classic examples of this are the Watergate Affair during the Nixon Presidency and the South Canyon Fire disaster. During Watergate, most of the players knew that what they were doing was wrong, but no one spoke up and said so, or stated their disagreement with these illegal actions. When asked why by the Senate Investigating Committee, they said such things as fear of "group pressure" or "being branded as disloyal." On the South Canyon Fire, firefighters discussed the Fire Orders and "Watch Outs" they were violating, but again, no one really spoke up. It is likely that they had similar fears to the Watergate group (e.g., fear of being branded not a team player, fear of being responsible for failure of the attack). In that disaster, 14 highly trained firefighters died!

Have you ever been to Abilene?

The author captures the essence of the paradox by the following short story. There was a family of four who lived 60 miles from Abilene, Texas. One hot summer afternoon, a member of the family made an offhand suggestion that they should go to Abilene for dinner. It is important to note that he didn't really want to go, but thought the others might be bored. After a couple of minutes of discussion, each member of the family agreed that they should have dinner in Abilene that evening. After a long hot drive and "not so good" meal, they returned to their home (Figure 1.10).

If people do not feel they can voice their true feelings, you may be on your way to Abilene.

Upon their arrival home, one family member stated, "It was a great trip wasn't it?" Another said, "To tell the truth I really didn't want to go, but you all pressured me to do it." The next person to speak said, "I didn't want to go either; I just went because all of you wanted to go." It was finally determined that none of the family members really wanted to go, but they did so because they thought that the others did. Have you ever been to Abilene?

What Jerry Harvey is trying to demonstrate with *The Abilene Paradox*, is that if members of a group do not voice their true feelings, or aren't allowed or encouraged to say what they really feel, an organization or group may develop a plan or pursue an action that is contrary to the true desires of the group members. We usually feel that conflict in an organization is one of the bigger issues a manager has to deal with. As Harvey points out, it is even more dangerous when an organization attempts to manage "agreement" that isn't really there.

Know the signs of the Abilene Paradox.

Abilene Paradox "Warning Signals"

According to Harvey, there are six symptoms displayed by an organization or group that is about to take a trip to Abilene. Think about situations you've been in where one or more of these warning signals have occurred. After reading the following, study the investigation report of the South Canyon Fire disaster, and see if the firefighters on the slopes of Storm King Mountain were on a trip to Abilene and didn't recognize it.

- Some members of the group agree in private about the nature of the situation or problem facing them, but don't

As a fire officer, you have to encourage your people to speak up and be heard.

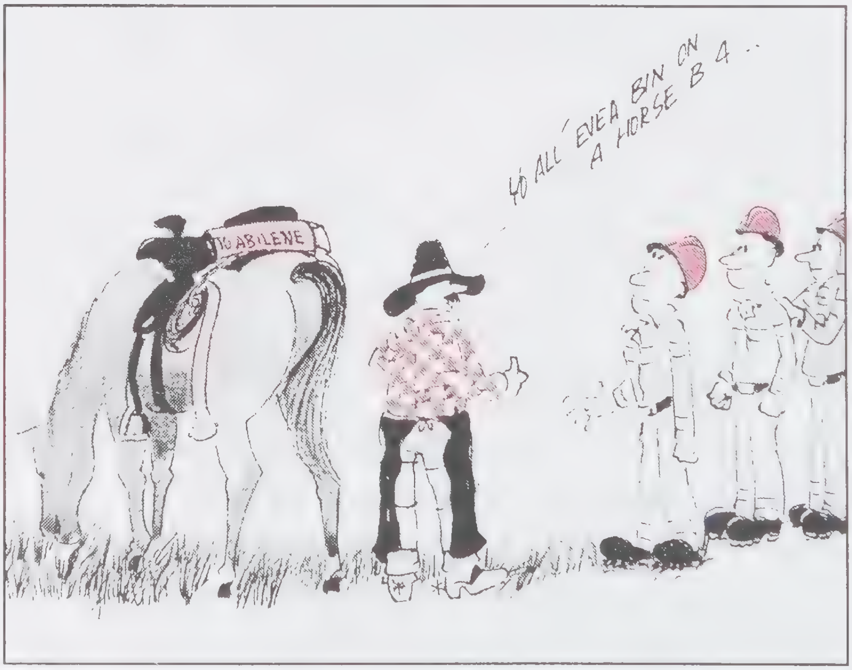

YO ALL' EVEA BIN ON A HORSE B 4 . .
TO ABILENE

Figure 1.10 This group of firefighters are on their way to Abilene. Each of them would rather be doing something else, but since they all "agreed," they're on their way. Managing "agreement" that doesn't really exist is more difficult than managing conflict.

communicate their opinions or positions to the whole group.

- Some members of the group agree in private about what steps would be required to cope with the situation or problem, but again, do not share this information with the whole group.
- Because members of the group fail to openly communicate their true feelings, beliefs, or desires to the whole group, they lead the other members to misperceive the "collective" desires of the group.
- With invalid and inaccurate information, the members make a collective decision that leads them to take actions contrary to what they really want to do, or know they should be doing.
- As a result of taking these actions, the group is counterproductive and ineffective. In the case of the South Canyon Fire, the actions (continuing a downhill attack) resulted in both death and injuries. Even if the consequences are less dramatic, the group will experience frustration, anger, irritation, and dissatisfaction with the organization. The group will divide into smaller factions that will blame both other group members and the leadership of the organization. Rarely will group members recognize their own responsibility for the flawed decision.
- The group cannot, or will not, recognize the real issue—the inability to identify and manage a flawed or illusory agreement; so the cycle repeats itself with greater intensity.

Rarely will a group recognize they are on a trip to Abilene.

Being anxious can influence your decisions.

Why it Happens

It doesn't seem to make sense that experienced personnel (firefighters or otherwise) take actions that are so contrary to their knowledge and desires. However, remember that the decision to take the action is based on a collective decision of the group; so to the group, the decision actually makes sense. Why do these things happen? Harvey has identified several psychological themes that influence individual decisions:

No one wants to be rejected.

- **Action Anxiety** - Have you ever avoided taking an action because it makes you intensely anxious (e.g., getting a flu shot, going to the dentist, or supporting a budget reduction that will impact your section)? If you have, you experienced action anxiety. Action anxiety can also cause you to follow a decision you don't agree with because, by avoiding conflict, you avoid anxiety.

We tend to think that the worst may happen because of our actions.

We are all fearful of the unknown.

- **Negative Fantasies** - Because of a negative fantasy or fear of group rejection, you may take an action which is contrary to your true beliefs. Because of the negative fantasy, you think that your opinion might lead to a negative response by the group or might erroneously change the direction in which you see the group heading. You do not voice your objections because the group may consider you wrong or foolish.
- **Real Risk** - It is human nature to think the worst may happen as a result of something we say or do. We misperceive the real risk of our actions. For instance, we think we will be fired if we speak up and voice a contradictory opinion. This has undoubtedly happened on occasion. But when was the last time a firefighter in your organization was fired for respectfully stating an opinion? So how real is the risk?
- **Fear of Separation** - We all fear being separated from our family, friends, or fellow firefighters. We may think that we fear the unknown, but Harvey says we actually fear the known: separation, alienation, and loneliness. So we avoid taking positions that would put us at risk of being branded "disloyal" or "not a team player."
- **The Psychological Reversal of Risk and Certainty** - This is a paradox within a paradox. By not being willing to take a risk and say what we really feel, we virtually ensure the separation and aloneness we so fear. Some of the firefighters on the South Canyon Fire were concerned about the dangers of constructing fireline downhill without adequate escape routes and safety islands. But, perhaps they were concerned that by speaking up they would be responsible for retreat and failure of the attack. So they stayed on the mountain, and the risk that so concerned them became reality.

Individuals impacted by the Abilene Paradox feel they are victims.

In order for the paradox to develop, the individuals involved must allow certain things, such as action anxiety, to control their actions. As noted above, the individuals involved generally don't blame themselves, but consider themselves victims. However, it is said, "It takes a real team effort to go to Abilene." Thus to attempt to blame someone else (such as the organization, the leadership, or other individuals) for your "trip," serves no useful purpose. It is ultimately you who are responsible.

In analyzing the underlying dynamics of the paradox, we see that group members usually understand the issues at hand, what needs to be done, and the consequences of certain actions. What is missing is the desire and sense of empowerment of individual members to confront the issues, to get a clear understanding of what really is at risk, and to share their genuine opinions and feelings.

Then who is responsible for getting the group out of Abilene? It isn't necessarily the boss, for it was a group decision that got you there (and the boss was only part of that decision). The power to break the "hold" of the group decision, must come from one of the group members. Someone has to step up and take a risk. Someone has to say, "I don't think it is wise for us to continue cutting line downhill under these conditions. We all know this is a dangerous situation and violates most of our training! We cannot continue this dangerous tactic!" Firefighters must be willing to take the risk and state what they know to be right. Fire officers must allow those under their command to feel comfortable with taking this risk.

Firefighters must feel free to speak out. Fire officers must allow them to.

Attacking the Paradox

How do you try to correct an existing group error? Since the "agreement" was made in a group setting, the correction should also take place in the group. One of the team, most likely the person who called the meeting (the confronter) must first own up to previously supporting the group decision, then share his or her true feelings. The other group members can then work through admitting their responsibility for the flawed decision. Ultimately a new solution or course of action that reflects the true desires of the group can be decided upon.

If the group decision is wrong, work toward correcting it.

Keep in mind that there is often more than one way to accomplish a particular goal. Fire officers will frequently have different opinions regarding which strategy and tactics to use. A legitimate difference of opinion is not the same thing as a group decision made in error because individuals fail to express their true feelings. As a group leader, you must be able to distinguish between the two. It's important to know your employees, encourage them to share their true feelings, and really listen to what they have to say. And you must be able to clearly think through any idea that your employees present to determine if it is a sound idea or one that will lead you into trouble.

Good decisions are the result of analyzing relevant facts.

The group that shares a passion for a common vision, and whose members believe they will be listened to respectfully, is much more likely to avoid a meaningless and unproductive "trip to Abilene." As noted many times, especially since the tragedy on Storm King Mountain, that vision **must** include a passion for safety.

Decision Making

There are three kinds of decision makers:

- Those who collect the facts and then decide on a course of action;
- Those who make decisions because they have the power to do so (but which aren't necessarily based on any meaningful facts); and
- Those who just can't make up their minds what to do (which is a decision in itself).

Define the problem.

Have you ever worked for people in these categories? Thank goodness most of the people who lead our organizations are those who make decisions based on facts. During emergency operations, however, you may often be required to make appropriate and timely decisions with limited and sometimes inaccurate information.

There is more than one way to solve a problem.

The decision-making process can be broken down into several steps. They are:

- **Defining the problem** - Defining the problem may not be as easy as you think. Begin by making sure that the problem you are about to solve is genuine. If you don't have confidence in the diagnosis of the problem, you will probably not have confidence in the solution.
- **Collect the needed information** - This does not just consist of the questions who, what, where, when, and why? You also need to know who will be affected by the decision, and how.
- **Generate alternatives** - There is usually more than one acceptable solution to a problem. In this step, develop as many practical alternatives as possible. Try to propose at least three potentially viable alternatives.

Review all alternatives.

- **Evaluate the alternatives** - Assess each of the alternatives and determine their merit. Consider how many people will be impacted by a decision. Is the decision consistent with the mission statement of the group or organization? Does the decision meet the goals and objectives of the task or project? What are the possible consequences of a poor decision? After answering these and other appropriate questions, rank the proposed decisions for probable successful outcome. Sometimes, "do nothing" may be a viable alternative.
- **Select one alternative** - An effective leader normally doesn't make decisions by a "committee of one." Rely on others to assist you in this task. This doesn't mean that you necessarily solicit input from everyone. However, involve your key staff, even (and perhaps especially) those who may disagree with you. Now comes the most difficult, but most important part: select one of the proposed alternative courses of action and implement it.
- **Review and control procedures** - Establish a process for assessing the ongoing success and appropriateness of the selected course of action. Be prepared to respond to changes or unanticipated glitches. Be flexible enough to change course if conditions warrant. Since emergency operations are frequently complex, and always evolving, several changes in the plan may be necessary before the emergency is successfully mitigated.

Change your plan if the situation changes.

Trust your "gut."

Another aspect of effective decisions is that they are made and implemented in a timely manner. In an emergency, you may have to make decisions very quickly. In those instances, you may have to rely on your knowledge, experience, and instincts. If you are experienced, your "gut instincts" are likely to be very appropriate and effective.

Factors Impacting Decision Making

In the past few years, various authors/fire experts have addressed the issue of the collapse of decision making. In these situations, there is increasing deterioration of the decision-making process and ultimately total collapse of the ability to think and act rationally under severe stress and danger. There is ongoing research on this phenomenon and proposals for minimizing it. While this is an important issue that deserves ongoing study, most

Most decisions that injure firefighters are actually made during the "normal pressures" of an emergency.

of the decisions that injure or kill firefighters are made when an individual is experiencing the normal pressures of managing an emergency.

Decision making can be complicated by personal pressures.

Operational decisions are complicated when the decision maker is "under-trained" and inexperienced. They are further complicated when the individual has personal problems, and/or feels "under-appreciated" and misunderstood at work. Supervisors should know their people and the pressures they are under. Supervisors are not only responsible for the training of their people, they should be aware of stress and poor morale which can negatively impact the safety and effectiveness of their people.

There appear to be three periods during which circumstances can contribute to either inappropriate decisions or ultimately the deterioration of the decision-making process. They are:

The decisions that you make before the fire, or early in the operation, may save your life.

- **Before an emergency or fire starts** - This may come in many forms: a severe budget reduction, the postponement of vital training, or failure to recognize the severity of a drought condition. Although these events don't have a direct impact on putting people at risk, they can be contributing factors.
- **During the early stages of an emergency** - As the pressures of an emergency begin to increase, decisions may be made regarding strategy and tactics that may eventually contribute to a disaster. These are the decisions that you have the most control over. Making the right decisions during this stage of an emergency, while conscious, rational thought is still operating, may well prevent a disaster if the situation drastically deteriorates.
- **At the point a fire "blows up"** - As firefighters become aware of impending danger, some may begin to panic; fear comes into play, and focus narrows. The ability to make sound, rational decisions may become severely diminished at this point.

Firefighters are only as good as their training.

As a fire officer, there isn't much you can do about budget reductions and managing their impact on operations. But training and keeping informed on the status of fuel and weather conditions are things you can and should deal with. You and your subordinates are only as good as your training, so don't neglect it. It doesn't have to be fancy or elaborate, just meaningful. Training should be so ingrained that safe, appropriate actions become automatic when panic begins to erode rational decision making. As noted above, staying alert to the status of fuels, current and forecasted weather conditions, and other potentially critical conditions is something you should routinely do to assist you in making sound decisions.

There are certain strategies and tactics that are especially dangerous. Take special care in these situations.

The stage is set for a real disaster when the selected strategy and tactics are incompatible with fire behavior at some later time during a fire. When you adopt a plan that may include some especially hazardous or dangerous strategies or tactics (e.g., downhill, indirect or undercut line construction, or frontal attack) you may be placing firefighters in harm's way. If you elect to construct fireline downhill, without having lookouts, anchoring the line, or burning out as you go, you are asking for real problems. To prevent or minimize the possibility of a disaster you should do two things: ensure that you are not violating any of the 10 standard Fire Orders; and take weather readings on a regular basis. Be sure that your action plan has contingencies for responding to the unforeseen. Take every possible step to stay "ahead" of the fire at all times.

As the level of fear increases, your focus narrows.

Let's assume that you have done everything you could to prevent a blowup from occurring, but it happens anyway. As discussed previously, as you and your firefighters become aware of impending danger, your focus narrows and your decision-making capacity greatly diminishes. Dr. Ted Putnam, of the USDA Forest Service, in his paper on the collapse of decision making on the South Canyon Fire, lists several indications that a collapse is occurring:

- Leadership is questioned and challenged.
- Decisions are questioned.
- The most experienced people on the fire are not being consulted.
- There is poor communication concerning the deteriorating conditions.
- The work force is fragmenting into small groups.
- There is a decreased level of discussion between groups.
- There is a failure to integrate vital, available information into plans.
- There is a failure to act on the weight of the evidence.
- There is an underestimation of current and potential fire behavior.

Once fear takes over, you revert to what is familiar. You may continue to carry your tools, even if it would be prudent to leave them behind, because you have always been taught to take care of (or keep track of) your tools. You will probably try to escape along the most familiar path—the way you entered the danger zone—even if it is not the safest route.

Planning in advance for what you will do if things go bad, is the first step to survival.

There are several things that can contribute to your safety and survival once fear has taken over: adequate time to move out of the area (awareness and lookouts); a well-established plan of escape (escape routes and safety zones); your subconscious skills (if training has been thorough enough to make appropriate responses automatic and ingrained); a strong, experienced chain of command (that can guide you to safety); and communications to link you with those who can think more clearly. Each of these is addressed in more detail below.

If you don't have time to escape, you won't!

Enough time to escape - Time is your enemy if you don't have enough of it to move to safety. It's important to post lookouts and to make sure that *everyone* stays alert for signs of impending danger, so that prompt warning can be given if there is a need to move to safety zones. And easy-to-reach escape routes leading to well-planned safety zones ensure the greatest chance of survival in a blowup or other disaster.

Your plan has to be realistic.

An escape plan - You should have a plan which addresses what will be done in the event that something goes wrong. The survival of 73 firefighters on the Butte Fire (see Chapter 6) was based on the fact that management had a plan. Firefighters had constructed safety zones at regular intervals along the ridgetop fireline. They were paying attention to everything going on around them so they had adequate time to reach their safety zones and survive with only minor injuries. The firefighters on the South Canyon Fire had a plan, but it was inadequate for the severity of the fire. Nor did they appear to be paying adequate attention to the warning signs of the changing weather and impending danger.

Your training and experience kick in - The purpose of training is to learn new techniques and to practice them so often that they become imprinted in your subconscious. You should train until the drill becomes automatic. When dangerous situations develop and your thinking becomes narrowed, you want your training and experience to kick in and assist in extricating you from danger. Again, on the Butte Fire, the investigators believe that 73 lives would have been lost if the managers on the fire had not been well-trained and experienced enough to anticipate the impending danger. They were able to order their firefighters to safety, with adequate time. The firefighters were also well-trained, which allowed them to respond quickly and maintain self-discipline in spite of the fear and anxiety they were experiencing. The Butte Fire is referred to repeatedly throughout this book, because this real event dramatically underscores the importance of training and a commitment to safety.

A strong and experienced chain of command takes charge - A strong and experienced chain of command can provide instructions and guidance that will protect the lives of firefighters. For this to work, leaders have to be constantly aware of what is going on and be knowledgeable enough to give timely, accurate instructions regarding escape plans. This is why it is mandatory that you have a functioning communications link with your supervisor and those around you.

If your communications system is flawed, you may not be able to get the word to move out in time.

Communication Links - You should always maintain a communications link with peers and supervisors, or you should halt what you are doing until a link has been established. Leaders must be in a position to immediately communicate any critical safety information, and everyone on the fire should be able to report changes and critical observations that only they may be aware of.

Leadership Techniques

The following pages deal with several issues that may crop up from time to time as you supervise personnel who bring various strengths and weaknesses to the job.

Performance, Conduct, Discipline, and Morale

As a fire officer, you are undoubtedly pretty good at firefighting. You know the skills, techniques, and drill. But what about the performance, conduct, and morale of your people? Do you know how to discipline in a constructive way?

Find out why people are not working to their full potential.

- **Performance** refers to the quality of an employee's work. There may be a problem with performance if an individual appears not to be working up to his or her capability. However, this may be the result of not having the necessary tools, equipment and/or supplies, or sufficient training to do the job. All you can ask of people is their best effort. If you know employees are not working up to their potential, or not pulling their weight, you should immediately attempt to identify the reason. A written plan of correction, with benchmarks, should be developed. A corrective action plan should involve the employees' input, and ideally, you should get their "buy in" to the plan. You may want to ask employees to evaluate their own performance, and then discuss any discrepancies between their evaluations and yours.

If misconduct occurs, take quick action to correct it.

- **Conduct** refers to the manner in which an employee acts or behaves (on or off the job). A problem with conduct occurs when an employee knows what is expected, but chooses not to do it. Misconduct may occur when an employee's conduct violates a law, regulation, or policy, or otherwise has a negative effect on the employer/employee relationship. All it takes is one "bad apple" to spoil the barrel and undermine morale. If misconduct occurs, take quick action to correct it. When dealing with situations such as lack of performance or misconduct, you should ask yourself the following questions: Who is not performing up to expectations and why? What is the performance standard, and is the person aware of it? What is the expected level of performance or conduct and the specific discrepancy? What are the consequences if the task is not completed to the established standard or level, or if the misconduct is not corrected? In attempting to resolve these situations, don't be afraid to ask for assistance or counseling from your supervisor. But, most of all, don't ignore the problem; it will not go away!

Consider discipline an opportunity for training.

- **Discipline** - There will come a time in every fire officer's career when he or she will have to discipline an employee. If you become aware of a deficiency in performance or conduct, you should promptly step in and correct the situation. The word discipline means "to teach." It should not be punitive, or done in such a way that the employee feels threatened or humiliated. Supervisors who are inconsistent or oppressive in the use of discipline not only alienate the employees involved, but create morale problems with the whole crew. Both performance and disciplinary counseling sessions should be carefully documented in writing. The documentation should include what the problem is, what is discussed, and the expected changes/outcomes. The employee should read and cosign the documentation. Be familiar with your organization's policies and procedures regarding performance reviews and disciplinary actions to ensure that you are in compliance with them.

- **Morale** - Morale should be of utmost concern to the fire officer. If morale is low, it may negatively impact performance, conduct, and safety. A good leader can create good morale; an inadequate or inconsistent leader can be the cause of poor morale. A fire officer has to develop a sixth sense about the cause of poor morale. The troops may have low morale, but it may not necessarily be a result of some action of the fire officer. It may be caused by lack of sleep, poor food, personal problems, or the actions of other employees or managers. Work with employees and help them through periods of low morale (Figure 1.11).

Don't underestimate the "power" of good morale.

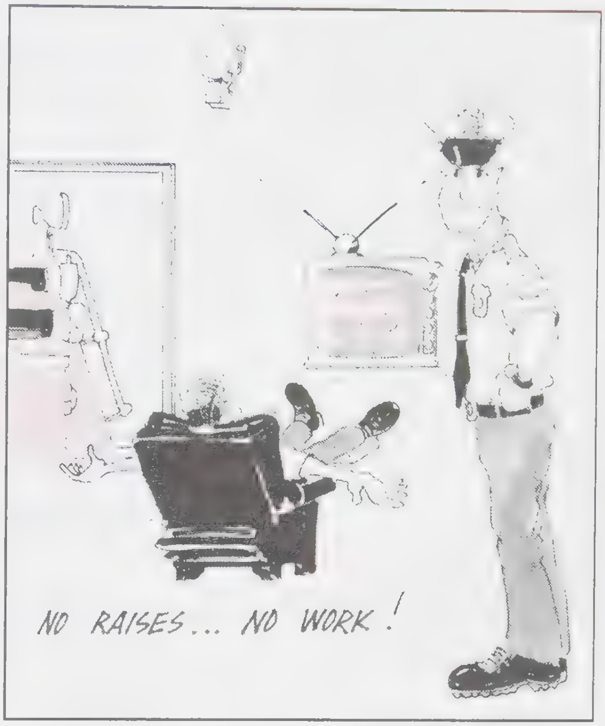

NO RAISES... NO WORK!

Figure 1.11 Lack of pay raises can be one cause of low morale, but other problems are more often the cause.

Praise and Reprimand

Sincere praise for a job well done can be a very powerful boost to morale. It is also one of the most common management tools that is overlooked or not practiced. Praise is a motivator and encourages new levels of performance. It helps to establish and reinforce the level of performance that is desired. Praise can improve productivity and the working environment, and can generate healthier attitudes. It also instills self-confidence in the individual or group.

To be most effective, praise should be given immediately after a good performance. You want a person or group to be able to easily relate the good job to the good word. You should be genuine in your praise. Employees see right through praise given just because it's a "good management tool."

Praising good work doesn't cost much.

Even if you don't hear a lot of praise from your supervisor, don't hold back positive feedback from your people. If you are not accustomed to giving praise, start now! Your reward will be the continuing good performance of your people, as well as their appreciation. Genuine praise and rewards foster respect and loyalty.

Documentation is very important in a disciplinary action.

Before you discipline an individual, make sure that you investigate the alleged action and confirm that it actually happened. As we discussed previously, discipline should be used as a teaching opportunity. If a reprimand doesn't work, however, you may have to resort to more formal discipline. This is more severe action on your part. You reprimand for serious infractions, by people who clearly know the rules or policies they are violating. You wouldn't normally reprimand the novice or trainee. When it is necessary to reprimand a person, do it as privately as possible. You don't want to humiliate the employee. You want to get him or her to change a behavior. As noted previously, carefully document the infraction and the expected corrective actions, and have the employee read and cosign the report.

Keep disciplinary actions a private matter.

You don't want to unjustly accuse someone of something he or she didn't do. It is normal for an employee to feel bad about being reprimanded. Ensure that when the session is over, the matter is laid to rest (as long as it is resolved). Don't keep bringing it up unnecessarily. To reprimand or discipline effectively, you don't have to shout or raise your voice. There is an old saying: "When you have the power, you can whisper." The more calm and nonjudgmental you are, the more likely the employee will react positively to the process.

If safety is being compromised, take immediate action.

It is normal to feel uncomfortable the first time you discipline someone. However, do not allow your discomfort to cause you to avoid the situation. Maintain a "nip-it-in-the-bud" attitude regarding discipline, or you will find that problems may snowball and get out of hand. Be firm, fair, and timely. Treat employees as you yourself want to be treated. A well-handled problem can breed more loyalty than you had before the negative incident.

Keep in mind that if safety is an issue, you must step in immediately to take corrective action before someone gets hurt.

Management by Wandering Around

As we discussed in the section on listening, the technique of management by wandering around is one that is so simple, yet so often overlooked. By getting away from your desk, or normal work station and going to where your people are, you not only see what is really going on, but you show employees that you care. Go to their work stations, visit, and chat. Allow them to tell you what is happening, and hopefully, what their problems are.

By spending time in the employees' work areas, you will be more likely to recognize the strengths and weaknesses of individuals or the group as a whole. By walking the fireline, you will be in a position to spot safety hazards that others may have missed or areas where additional training is necessary. You will find that being with the troops can be very rewarding.

Visit employee work areas. Be visible.

Dealing with Conflict

The Abilene Paradox dealt with false "agreement." But what if there is true conflict or disagreement in your group? How do you deal with that? How do you try to resolve the issue and make it a "win-win" situation?

When conflict surfaces, find out what the issues are.

The first thing to do is to ask all of the individuals in disagreement to outline their own positions and what they perceive to be the position of the other people. This will help you and them to better understand the problem. Just have them outline their thoughts, not write lengthy papers.

Next, try to agree on the source of the conflict and possible solutions. Engage your employees in the give-and-take of developing alternative positions that may be acceptable. Ask each person to list what the other person should do. See if there is a compromise position. If you are able to come to a compromise, test it to see if it matches with the goal of the whole group. Understand that you may have to convince various group members that people sometimes have to admit that they are wrong. Help your employees to save face by convincing them that changing a position may well show strength.

Have people write out their concerns.

If this doesn't work, have each person write out 10 questions for the others to answer. This will help identify each persons main concerns about the problem. The answers to the questions may lead to a solution.

Respect the experts, or the experienced people in the group. They may be quiet and hold back their comments. Draw them out.

Give their opinions more weight when the conflict involves their area of expertise, but don't rule out conflicting opinions.

Resolving conflict is not unlike trying to stay away from Abilene. The goal is to develop a plan that is acceptable to the group and best meets the objectives of the organization and the specific strategies and tactics for the situation at hand.

How to Run a Good Meeting

Know the difference between a briefing and a meeting.

There is a tendency in "semi-militaristic" organizations like the fire service to hold briefings, not true meetings. In a *briefing*, the "superior" chairs, controls, and usually dominates the proceedings. In a *meeting*, items are discussed in an effort to develop a plan of action. As a fire officer, you will routinely hold meetings (Figure 1.12). Here are some "do's and don'ts" for running a good meeting:

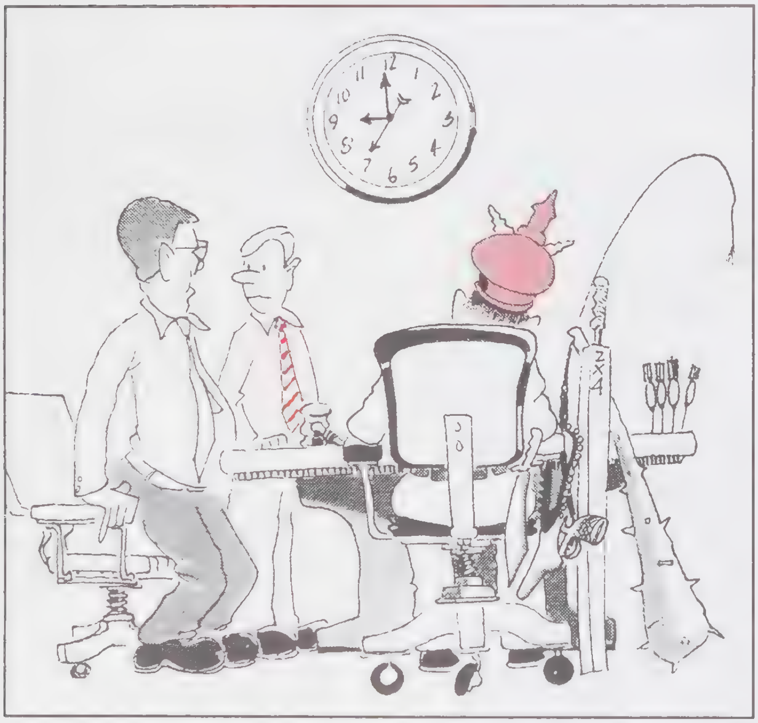


Figure 1.12 Being on time and in charge are not the best indicators of a good meeting.

- Don't compete with the group members. Give the ideas of others precedence over yours. If your ideas are to be the only ones discussed, close the meeting and hold a briefing.
- Listen to everyone. You may have to ask some of the more reserved and quiet ones, "What do you think?" or "How does that position make you feel?"
- Don't put anyone on the defensive. Assume that everyone's ideas have value.
- Control those who want to dominate the meeting. Don't alienate them, but be sure that you allow everyone to participate.
- The meeting will only be as productive as you make it. Realize that your level of interest and alertness will set the stage. Enthusiasm is contagious!
- Recap from time to time in order to keep all of the participants informed about where they are in the process and what is expected of them. Keep notes on flip charts or a board so that everyone can visualize what has been discussed. Be sure to record all decisions and recommendations.

- Check with the person who presented the problem to find out if an idea is worth pursuing or if a proposed solution is satisfactory.
- Give others a turn at conducting meetings. This will allow you a chance to participate in the discussion. Learning how to lead a group can help employees learn how to be better participants.

Give others a turn at conducting meetings. They will gain self-confidence and new skills.

There are times when even one-on-one meetings should follow some general guidelines. Examples are reprimands with subordinates and meetings with your supervisor for performance evaluations.

Giving and Taking Criticism

How should you conduct yourself to make reprimand discussions with subordinates meaningful? Here are some points to consider:

- See yourself as a teacher or coach—as being helpful. Keep in mind that you're trying to help someone improve.
- Show you care. Express your sincere concern about sharing ways the other person can boost his or her success.
- Pick the right moment. Never discipline or criticize someone in front of other people. Make sure the person hasn't just been shaken by some incident, or is otherwise anxious or upset.
- Avoid telling the person what he or she should do or should have done. "Shoulds" make you appear rigid and dictatorial.
- Avoid giving the impression that you're more concerned with following the rules than helping the person improve.
- Show how the person will benefit from taking the actions you suggest.
- Give specific suggestions. Being vague might only make the situation worse by creating anxiety and doubt.

Know how to take and give criticism.

There will be times when your supervisor needs to talk with you about your performance. You must be able to take constructive criticism yourself in order to be perceived as credible in the eyes of your employees. Here are some guidelines for making the discussion between you and your supervisor a successful one:

- Realize that it is not easy for your supervisor to discipline or criticize you. No one enjoys being the bearer of bad news.

Body language can be very loud.

- Separate your actions from your worth as a person. Your boss is questioning something you did, not who you are. The aim of discipline or criticism is to turn ineffective behaviors into effective ones.
- Practice "whole body listening." Remain quiet while your supervisor fully explains the issue. Let your supervisor know that you've understood. Send positive nonverbal messages such as nodding your head when your supervisor makes a point. Avoid negative signals such as squinting or shaking your head.
- Ask for examples if you don't fully understand the problem. Keep your voice neutral and nonthreatening. The more specifically you can define the problem, the more easily you'll be able to solve it.
- Repeat your supervisor's main points. If you've misunderstood anything, ask for clarification.
- Explain yourself if necessary, but don't make excuses.
- Request time to consider the criticism or action—and ask to meet again later. This is especially helpful if this discussion has caught you off guard, or if you need to do research to address the concerns.
- Don't just say that the behavior won't happen again. Explain how you will handle similar problems when they occur again. Let your supervisor know that you would appreciate more feedback.

There are times when firefighters need help getting through a stressful event.

Critical Incident Stress

From time to time, you and your people will have to deal with a situation that is very unpleasant and stressful (Figure 1.13). It may be the injury or death of a fellow firefighter, being involved with a nasty traffic accident, or the crash of an aircraft. Different events impact individuals differently. You, as a fire officer, should know how to recognize when such events may impact yourself or those you supervise.

A critical stress debriefing is not something that is accomplished without some real skill and experience. However, you can begin by getting people to start talking about their concerns. This is the first step in relieving them of the burden of the traumatic event.

A stressful event may cause an immediate or a delayed emotional reaction, and may take a brief or an extended period to resolve. Such events may trigger profound changes in an indi-

Figure 1.13 This fire officer is having a bad day and he may need a debriefing.

vidual. You probably have heard such reactions referred to as **post traumatic stress syndrome**. The reaction caused by very stressful, upsetting events may range from depression, anger, irritability, or withdrawal to increased use of sick time or increased consumption of alcohol.

You may react to a stressful event days/ weeks later.

Experts say it is best to prepare personnel for the possibility of this kind of reaction. Discuss what some of the potential reactions can be. If you have employees who are willing to share personal stories about their reactions to past incidents, this can be very helpful. However, always maintain the confidentiality of other employees if they do not wish to be identified. Emphasize that stressful events will have some negative effect on everyone involved, and that one of the best ways to put the event behind you is to talk about it with your peers.

Your people will be the key to your success.

When an extremely stressful event does occur, keep a close eye on your people. If the situation allows, relieve them often, taking them away from the scene to "regroup" their thoughts and emotions. Remember, if they are in shock over what they are having to deal with, they are very vulnerable. Tolerate any behavioral changes if they don't significantly interfere with the management of the incident. After the incident, work closely with them to help your employees resolve their reactions.

Following the incident, share your thoughts and experiences with your employees and ask them to share theirs. It is important that you and your personnel be good listeners, and that you are supportive, nonjudgmental, reassuring, honest, and accurate. Remind your employees of the fact that their reactions to the events they experienced may not really manifest themselves for some time.

You may need professional help.

Discuss the potential need for professional help with employees and your supervisor. Ensure that employees who need it, get assistance as soon as possible. Again, reassure employees that difficult and upsetting feelings and reactions are normal after such events, and encourage them to make use of all available support resources.

Now that you have learned some of the techniques for being a successful leader, the remainder of this handbook is intended to help you develop your skills as a wildland fire officer. Remember, you will be judged by how well you get others to work and produce for you. Your people are going to be the key to your professional success, and can be a great source of personal satisfaction if you practice good leadership and interpersonal skills.

2

Fire Weather

> ***"The cold front moved through the area at 3:20 p.m., with strong winds gusting to forty-five miles per hour. The fire activity immediately intensified with flame heights reaching 100 feet. Between 3:30 p.m. and 4:30 p.m., the fire reached "blowup" proportions."*** South Canyon Investigation Report

In this chapter, you'll

- *Gain an understanding of the relationships between the various weather factors.*
- *Learn how terrain and aspect influence weather.*
- *Learn how to "read" the weather.*
- *Come to understand the importance of observing and analyzing weather on the fire ground.*
- *Learn to recognize the visual indicators of impending weather changes.*
- *Learn how weather affects fire behavior.*
- *Begin to understand some of the weather "conditions" which can indicate potential danger.*

This chapter contains a considerable amount of general information on weather and how it is created. Weather is the primary driving force behind the changes in fire behavior. Although current and predicted weather forecasts should be available to you, being familiar with the underlying dynamics can help you better understand the potential impact of these forecasts on a wildland fire.

Weather changes, even subtle ones, are killing or injuring wildland firefighters each year. If you don't know and understand the actual and predicted weather parameters, you will not be able to predict what a fire is going to do, and will have difficulty developing sound, effective suppression strategies. You might as well fight fire with your eyes closed. More importantly, you need to closely monitor the weather, and know when and why changing conditions require different tactics to protect the safety of your firefighters.

The earth's atmosphere is very dynamic. Today's weather and tomorrow's predicted weather are but snapshots of atmospheric conditions. These conditions are influenced by temperature, humidity, rain, wind, etc. Understanding these factors, and how a change in one or more of them can change the "big picture," is necessary before you can successfully manage a fire.

If you don't know what the weather is, you might as well fight fire blindfolded.

Have you ever seen a picture of the earth (Figure 2.1) taken from space and noticed that everything was in motion? The clouds move and circle around constantly. This also happens above "your piece of fireline" to a lesser extent. Rest assured, changes in weather will take place. It is your job to detect these changes and to develop a sense of what is going to happen and when. As a fire officer, you are responsible for the lives of your firefighters. As noted previously, for their safety and for your own, you must observe and respond appropriately to the weather.

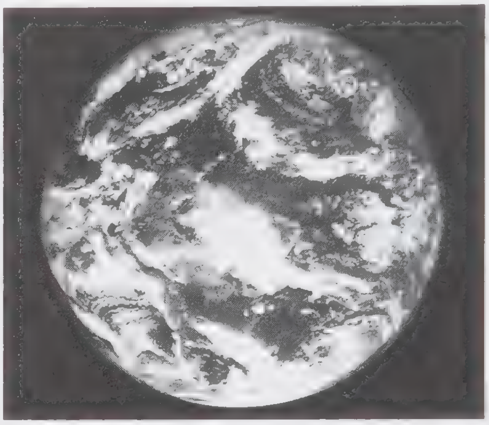


Figure 2.1 A picture of earth from space. Visualize the clouds traveling in waves, moving across the land and sea.

The Big Weather Picture

21% of the atmosphere is oxygen.

We take for granted the air we breathe and believe the adage that if we wait a minute, the weather will change. What is air? Why does weather change, and how does this impact the decisions of the fire officer? The atmosphere is an "ocean" of air, with currents, waves, and depth. It contains the oxygen we breathe and the carbon dioxide used by plants. It protects us from the harmful rays of the sun, and keeps us warm at night. Yet while it is doing this, it is constantly moving and changing.

The troposphere is the atmospheric layer closest to the earth's surface.

The atmosphere consists of several layers. The layer of atmosphere closest to the ground is called the **troposphere**. All weather phenomena (e.g., thunderstorms, wind, humidity, etc.), as we know them, occur within this 5 to 10 mile thick layer (Figure 2.2). The air within the troposphere contains these elements:

- 78% nitrogen
- 21% oxygen
- 0.9% argon
- 0.03% carbon dioxide
- dust and salt particles
- water vapor
- smoke
- volcanic ash
- pollutants

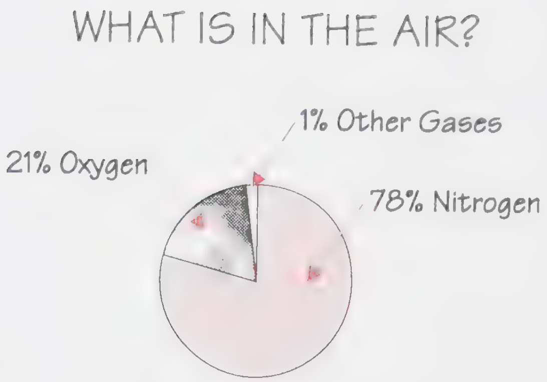


Figure 2.2 The makeup of the atmosphere.

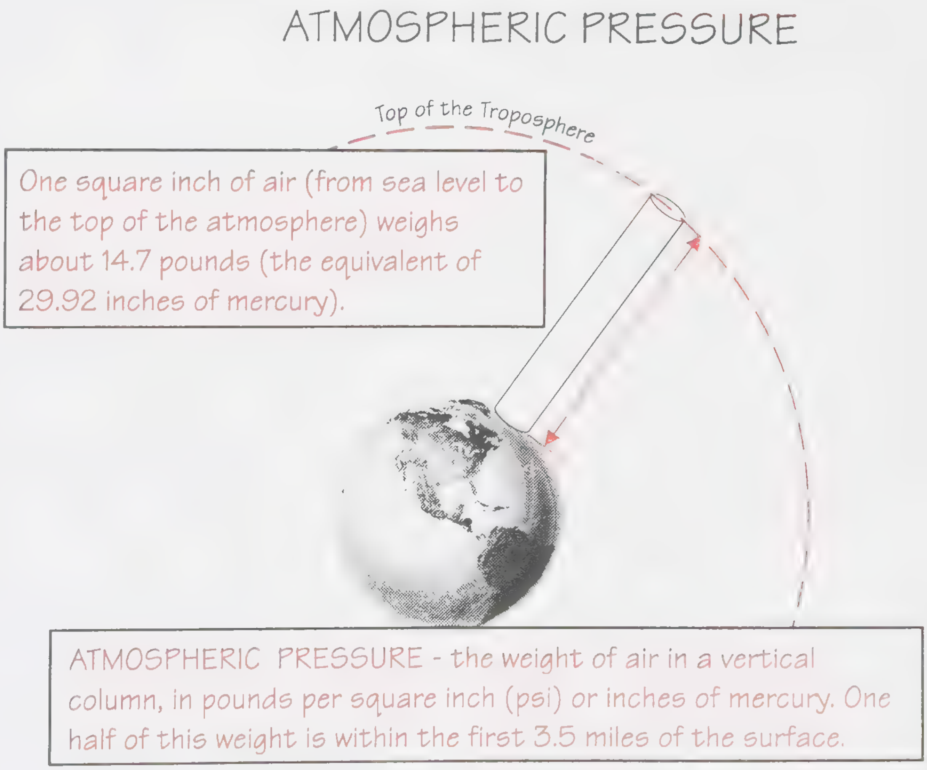
From a wildland firefighting perspective, the two most important components of the atmosphere are oxygen, and water vapor. Oxygen is essential for combustion and water vapor causes clouds, rain and humidity.

Atmospheric Pressure

Even air weighs something. A one inch square column of air the full depth of the atmosphere weighs about 14.7 pounds (Figure 2.3). This is equal to a 29.92 inch column of mercury, and is considered the normal or standard atmospheric pressure at sea level. Most barometers measure atmospheric pressure in "inches of mercury." About one-half of the weight of the atmosphere is within 3.5 miles of the earth's surface.

Atmospheric pressure varies with elevation above the earth's surface. The higher the elevation, the lower the atmospheric pressure. One example of the significance of this concept can be found in aviation. Pilots determine the elevation of an aircraft above sea level with an altimeter. Al-

Atmospheric pressure varies with elevation.



One square inch of air (from sea level to the top of the atmosphere) weighs about 14.7 pounds (the equivalent of 29.92 inches of mercury).

ATMOSPHERIC PRESSURE - the weight of air in a vertical column, in pounds per square inch (psi) or inches of mercury. One half of this weight is within the first 3.5 miles of the surface.

Figure 2.3 The weight of air is 14.7 pounds per square inch. Atmospheric pressure varies with elevation. The higher the elevation, the lower the atmospheric pressure.

though the pilot is reading "elevation," the altimeter is actually sensing atmospheric pressure.

Atmospheric pressure also varies in relationship to weather phenomena called "highs" and "lows" which can be measured with a barometer. Knowing the barometric pressure at a specific location can help weather forecasters track high and low-pressure areas, and the changes that can be associated with their movements and strengths.

The Weather Engine

The sun is the ultimate source of weather.

The sun is the ultimate source of weather. The conduit for this action is solar radiation energy. Solar radiation strikes the earth on a 24-hour cycle. Most solar radiation strikes earth during the day and is radiated back out at night. However, some of the heat is retained by the earth and its oceans, minimizing wide swings in the earth's temperatures.

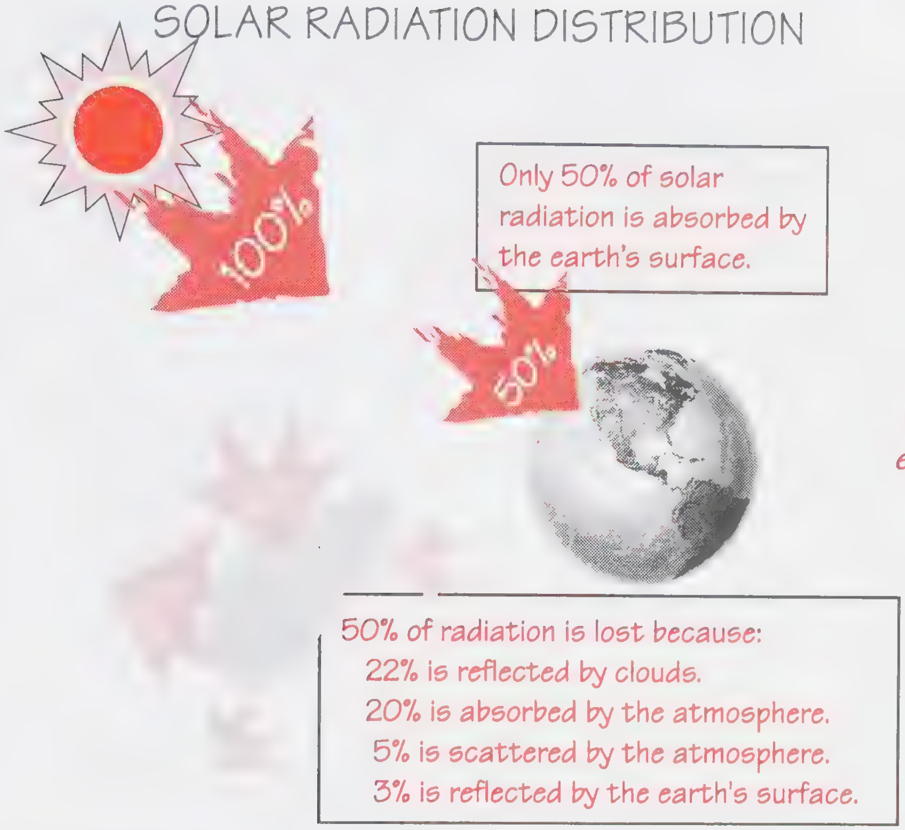
Most solar radiation strikes the earth during the day and is radiated back out at night.

The amount of heat energy that reaches the earth varies depending on location, atmospheric conditions (e.g., clouds, moisture, pollution) and surface orientation or aspect (e.g., south, north). On average, 50% of the sun's energy reaches the earth's surface, 20% is absorbed by the atmosphere (clouds, water vapor or pollutants), and 30% of the energy is reflected back into space. To maintain a favorable climate, the daily outgoing radiation must equal the incoming solar radiation (Figure 2.4). This process is called heat balance. Without it, the earth would become progressively warmer or cooler. However, not all parts of the earth maintain a balance (Figure 2.5). The polar caps lose more heat than they gain and the equatorial region gains more heat than it loses. This imbalance partially drives the dynamics and movement of what we call weather fronts.

Increases in surface temperatures are the primary source of weather.

The force that drives the earth's "weather engine" is the increase in the surface temperature from site-to-site and day-to-day. The four primary factors that influence these temperature changes are:

- The amount of moisture and/or pollution in the air. These elements absorb and/or reflect solar radiation. The presence and thickness of clouds, water vapor, and smoke reduces the amount of solar radiation heat that reaches and leaves the earth's surface.



Only 50% of solar radiation is absorbed by the earth's surface.

50% of radiation is lost because:
22% is reflected by clouds.
20% is absorbed by the atmosphere.
5% is scattered by the atmosphere.
3% is reflected by the earth's surface.

Figure 2.4 The amount of solar radiation that strikes the earth is related to the level of cloud cover.

About 50% of the sun's energy reaches the earth.

- The angle between the surface of the earth and the sun. If the sun is directly above and at right angles to the earth, more energy will reach the surface. As the sun moves through its daily arc, or is in the southern or northern latitudes, the angle is greater, thus the radiation is reduced. Latitude, slope, aspect, elevation, and shape of the terrain can also significantly change the earth's temperature. The changing angle of the sun, influenced by the earth's axis, is what causes the change in seasons. Changes in the earth's axis help balance the overall heating of the earth, because they provide for a greater distribution of heating (Figure 2.6).

Latitude, slope, aspect, elevation, and shape of the terrain also influence the earth's temperature.

The highest temperatures usually occur between 1400 and 1600 hours.

- The lag time between when solar radiation strikes the earth and when the heat is radiated back out into space. This time varies both throughout the day and throughout the year. The greatest amount of solar radiation reaches the earth around noon, but the highest temperatures usually occur between 1400 and 1600 hours. Likewise, the most solar radiation reaches the earth's northern hemisphere in June, but the hottest part of the year is in July. The lag time in both daily and seasonal temperatures can be explained by the follow-

The daily incoming and outgoing radiation balance.

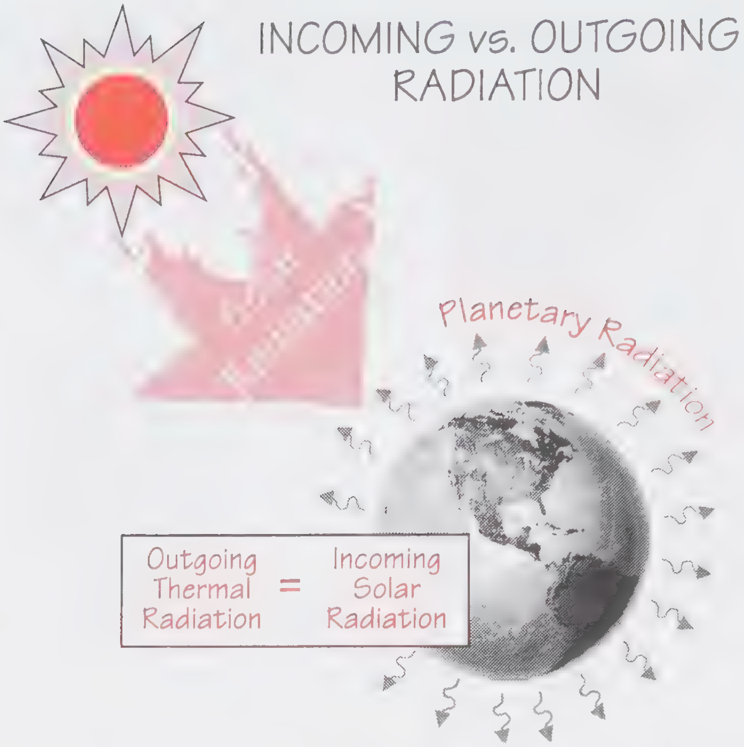

INCOMING vs. OUTGOING RADIATION
Planetary Radiation
Outgoing Thermal Radiation = Incoming Solar Radiation

Figure 2.5 The earth gains heat during the day and loses it at night. This gain/loss is what keeps the earth's overall temperature in balance.

The angle between the sun and the surface of the earth changes with the time of year.

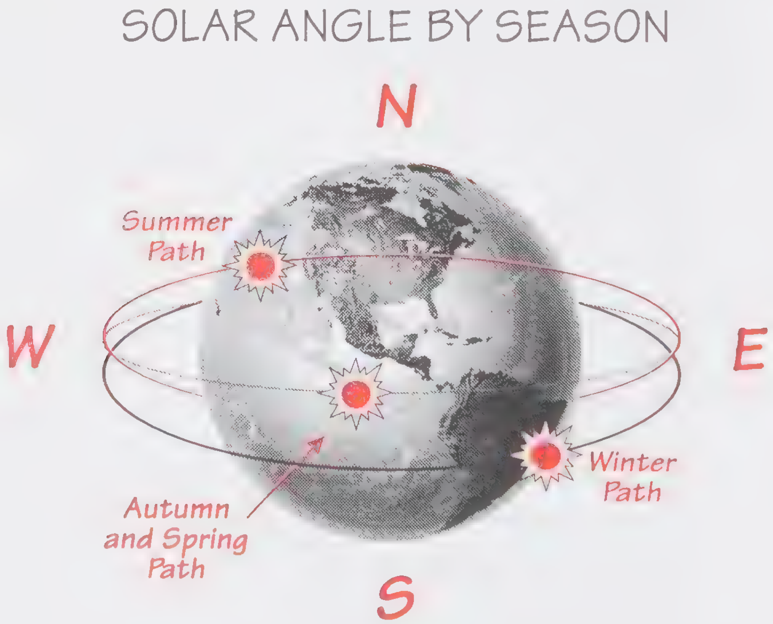

SOLAR ANGLE BY SEASON
N
Summer Path
W
E
Winter Path
Autumn and Spring Path
S

Figure 2.6 The angle at which solar radiation strikes the surface influences the level of heating. The axis on which the earth rotates helps even out the amount of solar radiation that hits the earth.

ing: The earth loses heat continuously through radiation. However, when the incoming energy from the sun exceeds the outgoing energy from the earth (e.g., around noon each day, and during the summer), the temperature continues to rise because the earth is receiving more heat than it is losing. The temperature doesn't start cooling off until the incoming energy ceases to be greater than the outgoing energy (Figure 2.7).

- The surface properties of the terrain and/or vegetation. The color, texture, transparency, etc. of the surface receiving the solar radiation, absorb and/or reflect it to different degrees (Figure 2.8).
  - Color and texture - Both the color and texture of surfaces influence how they absorb or reflect solar radiation heat energy. Black surfaces (like dark soil) absorb more energy than white ones (like dry grass and weeds). Rough surfaces (like tree bark) absorb more energy than smooth ones.
  - Transparency - The greater the transparency of a surface the more solar energy is able to penetrate the medium. This is why water absorbs and holds more heat energy than rock.
  - Conductivity - The greater the conductivity of a material (rock vs. wood), the more deeply heat energy is absorbed by it.

There is a lag between when the most solar radiation reaches the earth and when the temperature is the highest.

When incoming energy exceeds outgoing energy, the temperature will begin to rise.

The color, texture and transparency of the earth's surface absorb/reflect solar radiation to different degrees.

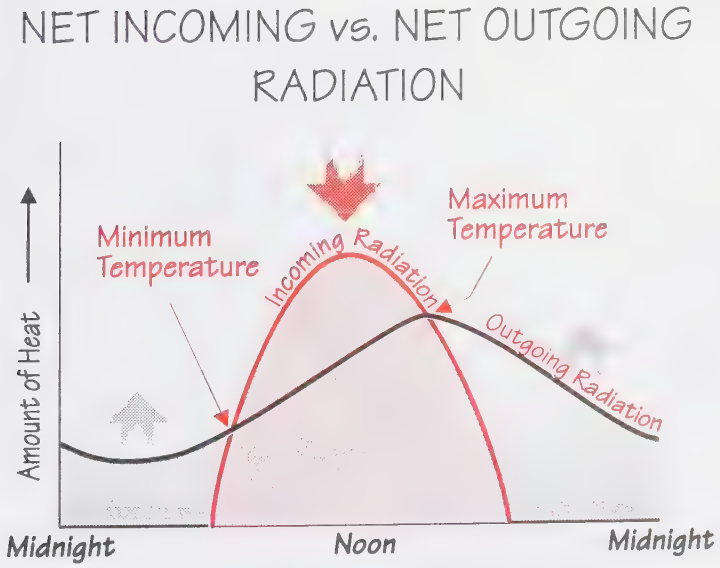
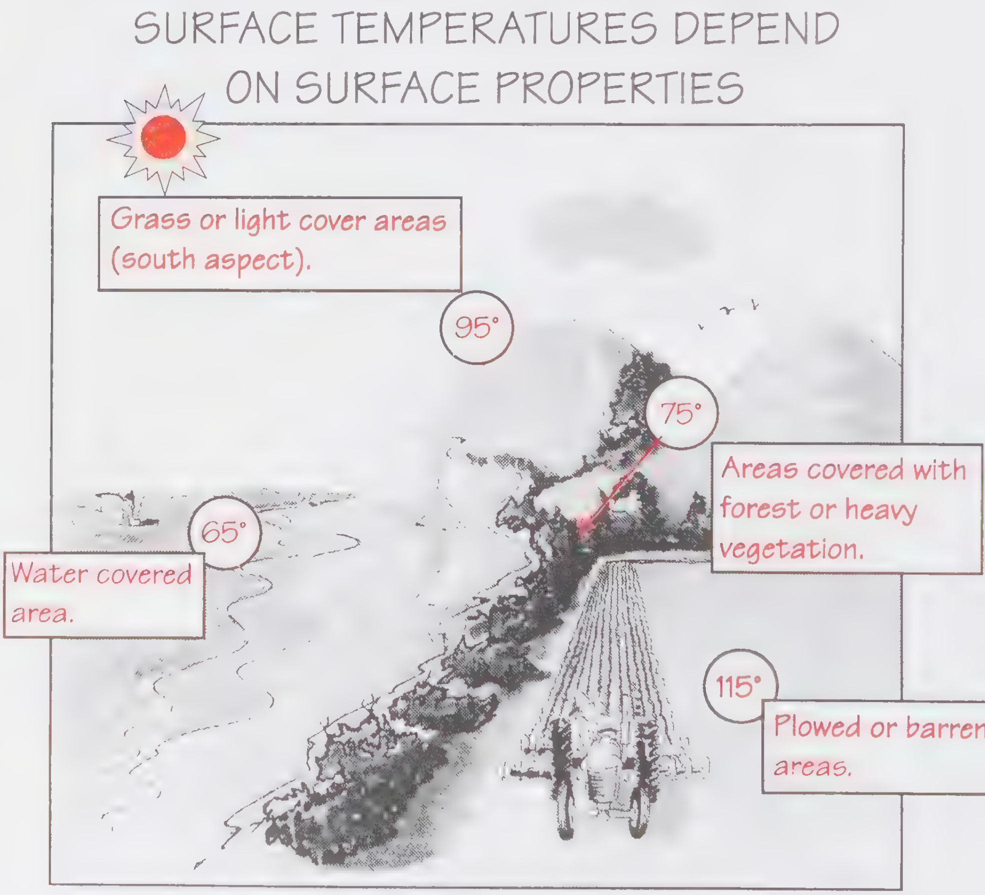


Figure 2.7 When the incoming solar radiation exceeds the level of outgoing radiation, the temperature of the atmosphere will rise. The hottest part of a day will occur after the period during which the earth receives its greatest level of solar radiation.

- Absorbed heat - Some material absorbs and retains heat more efficiently than others. Water can absorb five times the heat energy of rock, and holds heat longer.
- Surface moisture - Evaporating moisture has a cooling effect. During condensation, heat is released.

Water absorbs five times the heat energy of rock and retains the heat longer.

Note how different the surface heating can be, depending on the type of surface. Water is the coolest (at 65°) because it is being heated to a greater depth, thus dispersing the solar energy. Further, it is a better "retainer" of heat. The shaded forest is a little hotter (at 75°) followed by the grass/brush surface (at 95°). The plowed field is the hottest (at 115°) because of its color, texture, and lack of shade and transparency. All of these areas will impact fire behavior in different ways: a fire will move up the grass/brush slope much faster than it will move across the forested area. The heat of the plowed field may cause upcanyon winds, and if the air is unstable, may even cause whirlwinds. As


SURFACE TEMPERATURES DEPEND ON SURFACE PROPERTIES
Grass or light cover areas (south aspect).
95°
75°
Areas covered with forest or heavy vegetation.
65°
Water covered area.
115°
Plowed or barren areas.

Surface temperatures in an area may vary from 65° to 115° depending on the surface material.

Figure 2.8 The surface temperature is dependent on the type of surface, type of ground cover, aspect and cloud cover.

the time of day changes, or as cloud cover changes, all of these temperature relationships will change.

Approximately thirty percent of the solar radiation absorbed by the earth is radiated back into the atmosphere. The rate at which this energy is lost is controlled by the amount of water vapor in the air. Variations occur during periods of higher humidity or when clouds are present. During cloudy periods, the amount of heat energy that is radiated back into space is less than on clear nights. The greatest amount of heat is lost at night when there is no cloud cover and the air is relatively dry. This is why the temperature swings in the desert are so wide from day to night (Figure 2.9). Some heat is lost to the air through convection and conductivity. The condensation of dew also releases heat when it changes from water vapor to liquid.

About 30% of solar energy is radiated back into the atmosphere.

Relationship Between Atmospheric Pressure, Volume, and Temperature

The relationship between atmospheric pressure, the volume or density of the air mass, and air temperature, drives all changes in weather. Weather circulation results from differences in the

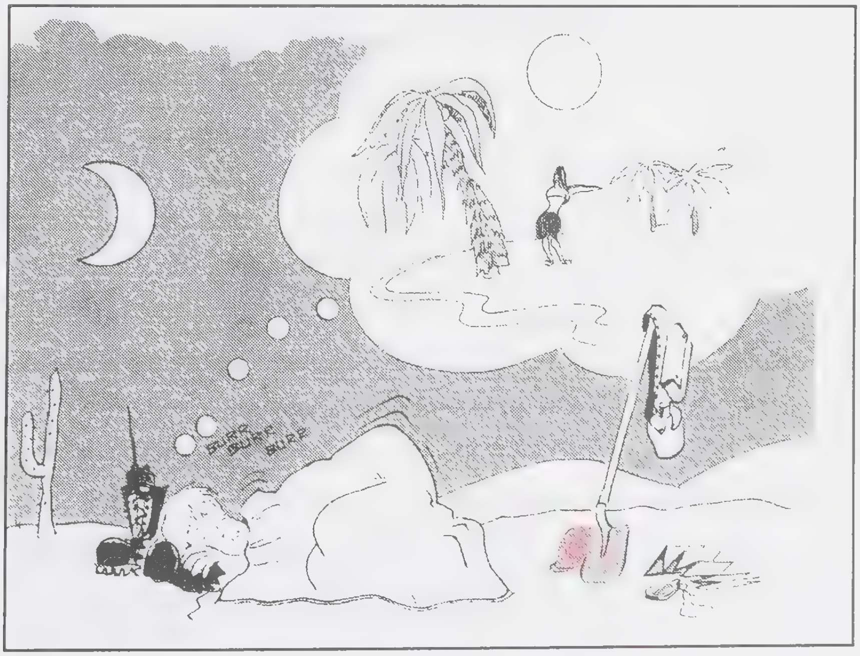


Figure 2.9 It is much colder at night in the desert because of lack of clouds and low air moisture content. Much different conditions can be found on a tropical island!

Clouds and low humidity limit the amount of energy that is radiated back into space; that is why there are large temperature "swings" in the desert.

amount and use of the sun's energy. In order to understand why and how weather changes, it is critical that you understand how air reacts to changes in temperature and how these temperature changes affect both the pressure and density (volume) of the air. All winds, storms and clouds are the result of these relationships. The reaction of air (which is a gas) to a change in temperature is predictable. This relationship is described by the equation $PV=MRT$. This formula is called the Ideal Gas Equation (Figure 2.10). Its only importance to you as a fire officer is to show that there are strong relationships between weather factors that affect fire behavior.

Atmospheric pressure, density, temperature and relative humidity are directly related.

If there is a change in atmospheric pressure, the temperature and volume of the associated air mass also change. If a mass of air is lifted vertically in the atmosphere, its volume will increase and its temperature will decrease. Conversely, a descending mass of air will become warmer and decrease in volume because of an increase in atmospheric pressure. Air expands and cools as it is lifted; it warms and compresses as it descends to lower elevations (Figure 2.11). All of these changes conform to the relationships represented by the Ideal Gas Equation.

If one factor in the formula changes, other factors also change.

IDEAL GAS EQUATION

$$PV = MRT$$

$$(\text{Pressure} \times \text{Volume}) = (\text{Mass} \times R_{\text{a constant}} \times \text{Temperature})$$

Figure 2.10 The Ideal Gas Equation describes the relationship between the temperature, pressure and volume of a gas.

Atmospheric pressure, volume and temperature are also related to density; warming is associated with a decrease in density, while cooling is associated with an increase in density. Cooler air is denser, and sinks when surrounded by warmer air. Warmer air is lighter (less dense), and will rise. This is a very important concept because all weather processes can be attributed to this phenomenon (Figure 2.12).

As air rises its volume increases and temperature decreases.

It is critical that you have a good understanding of how atmospheric temperature, pressure, volume and density affect

COOLING AND EXPANSION OF AIR LIFTED VERTICALLY

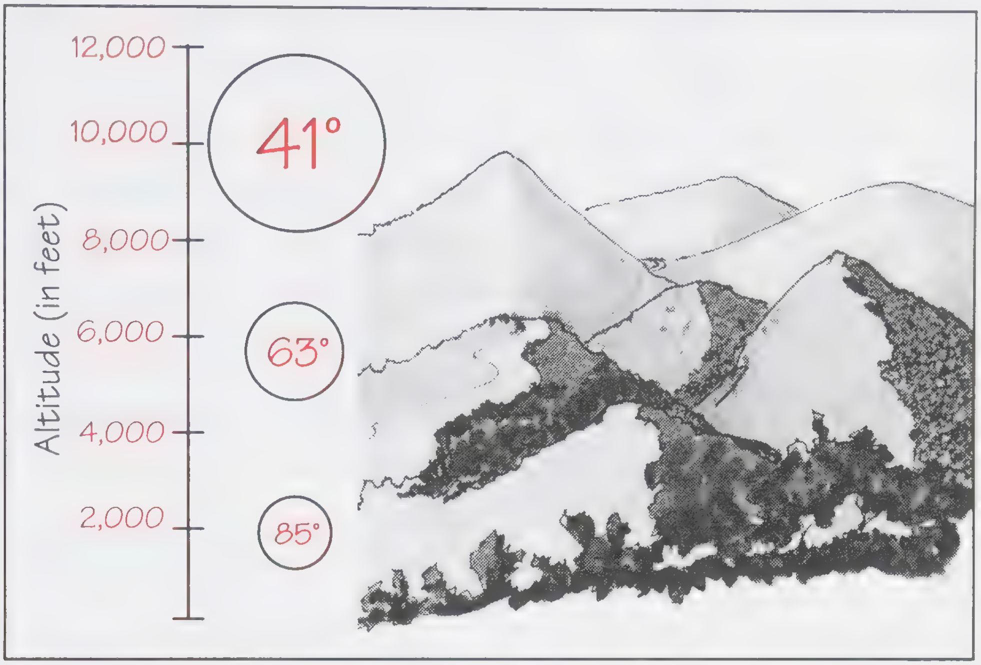


Figure 2.11 Note the relationship between the volume and temperature of the air at various elevations.

each other, and how these factors affect atmospheric stability and wind. All winds, both large scale and small scale, are caused by differences in temperature and density. As these forces within the atmosphere try to "equalize," winds are created (Figure 2.13).

All winds are caused by differences in temperature and density.

Relationship between Temperature and Humidity

Temperature is defined by Webster's Dictionary as "degree of hotness or coldness measured on a definite scale." Temperature is also an indicator of the molecular activity of a substance. Humidity is defined as "a moderate degree of wetness especially of the atmosphere." You can see from these definitions, and the relationships established in the Ideal Gas Equation that these weather factors must be discussed together. The temperature of the air is directly related to how much moisture the air can hold.

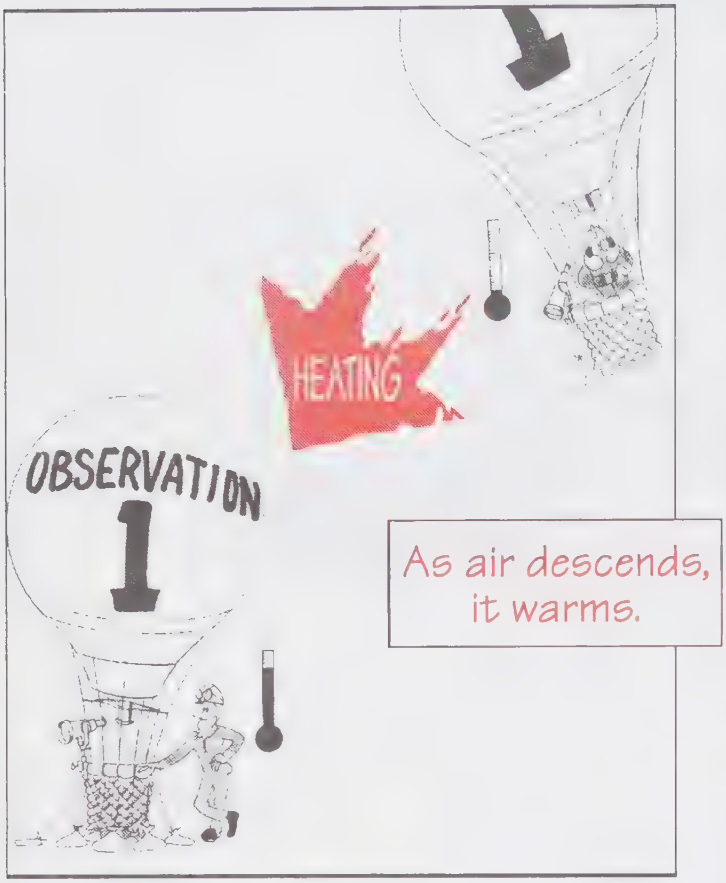
Temperature is an indicator of molecular activity.

As noted earlier, the surface of the earth is heated by solar radiation each day. However, this heating is not uniform. The amount of heating is governed by the amount of moisture and pollutants in the air: the angle of the sun; and the type, color, texture, etc. of the surface being radiated.

Moisture in the atmosphere can appear in three states: solid (snow or ice crystals), liquid (rain) and gaseous vapor (water vapor). We can easily measure the amount of rain or snow that falls to the earth. However, water vapor is measured (or calculated) as the percentage of moisture in the air. The moisture in the air has a direct effect on fuel moisture and fire behavior.

The primary source of moisture in the atmosphere is the ocean. lakes, rivers, and other smaller bodies of water also contribute to the moisture in the atmosphere, though to a lesser degree. Yet another source of moisture is transpiration of plants—water vapor which is given off during their metabolic processes, similar to the moisture human beings give off when exhaling or sweating.

DESCENDING AIR WARMS



As air descends, it warms.

Figure 2.12 The temperature of an air mass will vary depending on changes in elevation. Notice how air heats up as it descends. This change can be related back to the Ideal Gas Equation and the relationship between pressure and temperature.

The primary source of moisture is the ocean.

WEATHER CONTROLLING FACTORS

- Compression of the atmosphere results in warming, while expansion results in cooling.
- Colder air is denser and sinks when surrounded by warmer air.

All weather processes can be attributed to one or both factors.

Figure 2.13 The basis of all weather changes can be found in these two weather controlling factors.

Dew Point is the temperature at which the air is 100% saturated with water vapor, and either begins to condense into clouds or fog, or begins to form dew. If the air temperature goes up, the dew point remains constant, but the air becomes dryer. When the dew point temperature is high, the air has much more moisture in it than if the dew point temperature is low (Figure 2.14).

Dew point is the temperature at which the air is saturated.

If you know the dew point, you can determine how much moisture there is in the air at a given temperature. An air mass with a dew point of 75° has considerably more moisture in it than an air mass with a dew point of 45° (Figure 2.15). You should be concerned if the dew point temperature is decreasing over time. This means the air is becoming dryer, and this change may impact fire behavior. If you know the dew point and temperature, you can determine the relative humidity of an air mass. If you know the dew point or relative humidity, and the predicted afternoon temperature, you can predict the afternoon relative humidity.

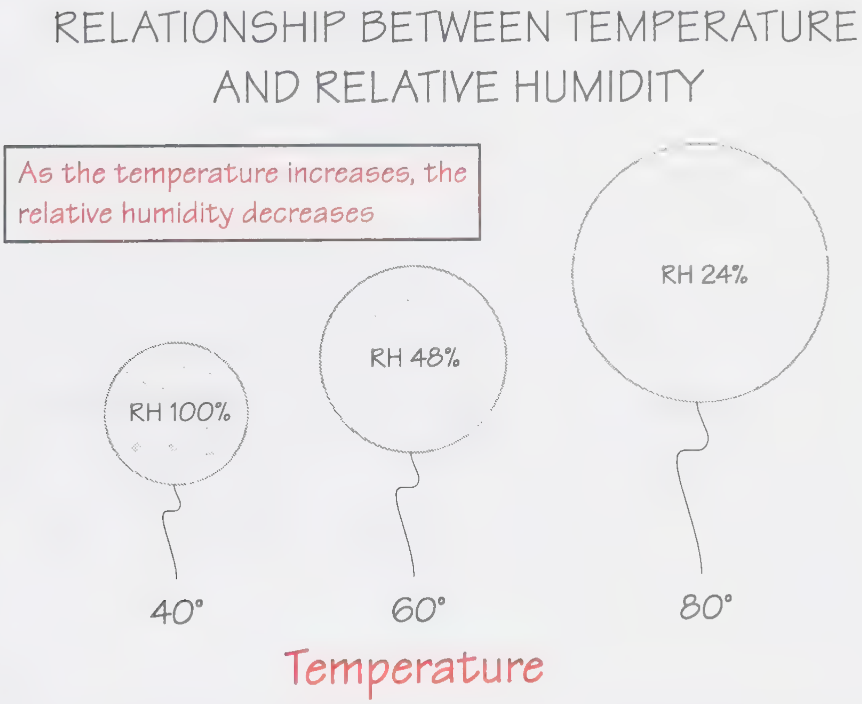
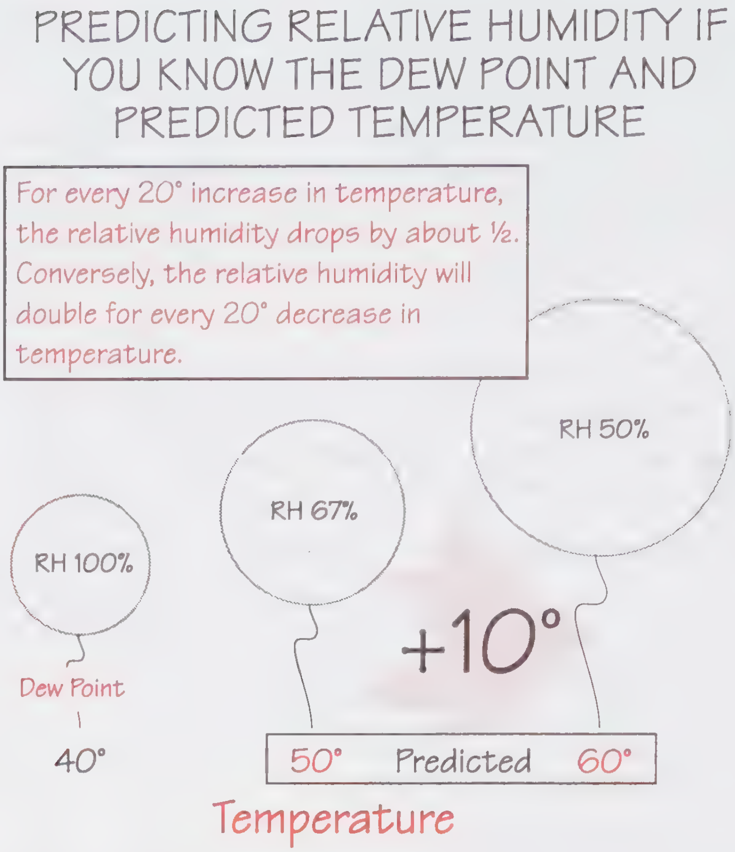

RELATIONSHIP BETWEEN TEMPERATURE AND RELATIVE HUMIDITY
As the temperature increases, the relative humidity decreases
RH 100%
RH 48%
RH 24%
40°
60°
80°
Temperature

Figure 2.14 As the temperature rises, the dew point (temperature at which the air is saturated) remains constant, but the percentage of water vapor per volume of air decreases).

The amount of moisture in a specific air mass is constant. The relative humidity will vary as the temperature changes.

If you know the dew point, and predicted temperature, you can predict the relative humidity.

For every 20° increase in temperature, the relative humidity will drop by ½.


PREDICTING RELATIVE HUMIDITY IF YOU KNOW THE DEW POINT AND PREDICTED TEMPERATURE

For every 20° increase in temperature, the relative humidity drops by about ½. Conversely, the relative humidity will double for every 20° decrease in temperature.

Figure 2.15 The dew point of this air mass is 40°. If the temperature is predicted to be 60° later in the day, the percent of moisture per volume of air will be cut by 50 percent.

Warm air can hold more moisture.

Warm air can hold more moisture. So, as the air temperature rises during the day, the relative humidity will decrease and have an impact on fire behavior. Conversely, as the temperature decreases during the evening and night, the relative humidity will increase.

When the temperature cools, the relative humidity will increase.

Wet Bulb Temperature

As water evaporates, it cools. This cooling is measured as the wet bulb temperature, the lowest temperature to which the air can be cooled by evaporating water. Wet bulb temperature is determined by using a psychrometer. A psychrometer consists of a pair of thermometers, one to record the dry bulb temperature and the other to record the wet bulb temperature. A wick which has been dampened with water is placed over the end of the wet bulb thermometer. Heat from the air changes the water to vapor. The wet bulb is cooled as moving air evaporates the water. The drier the air, the larger the difference between the dry and wet bulb readings.

Once you know the dry and wet bulb temperatures, you can determine the relative humidity and dew point. Charts have been developed for this purpose (Figure 2.16). Remember that atmospheric pressure is also a factor that must be considered, so these charts are for specific elevation ranges.

The use of these charts is simple. Be sure that you have the chart for the appropriate elevation range. Move down the left margin of the chart to the line that corresponds to your dry bulb temperature. Then move to the right across the chart to the column that represents your wet bulb reading. The two numbers in

The drier the air, the larger the difference between the dry and wet bulb readings.

RELATIVE HUMIDITY and DEW POINT TABLE

(Elevation range 501 to 1900 feet)

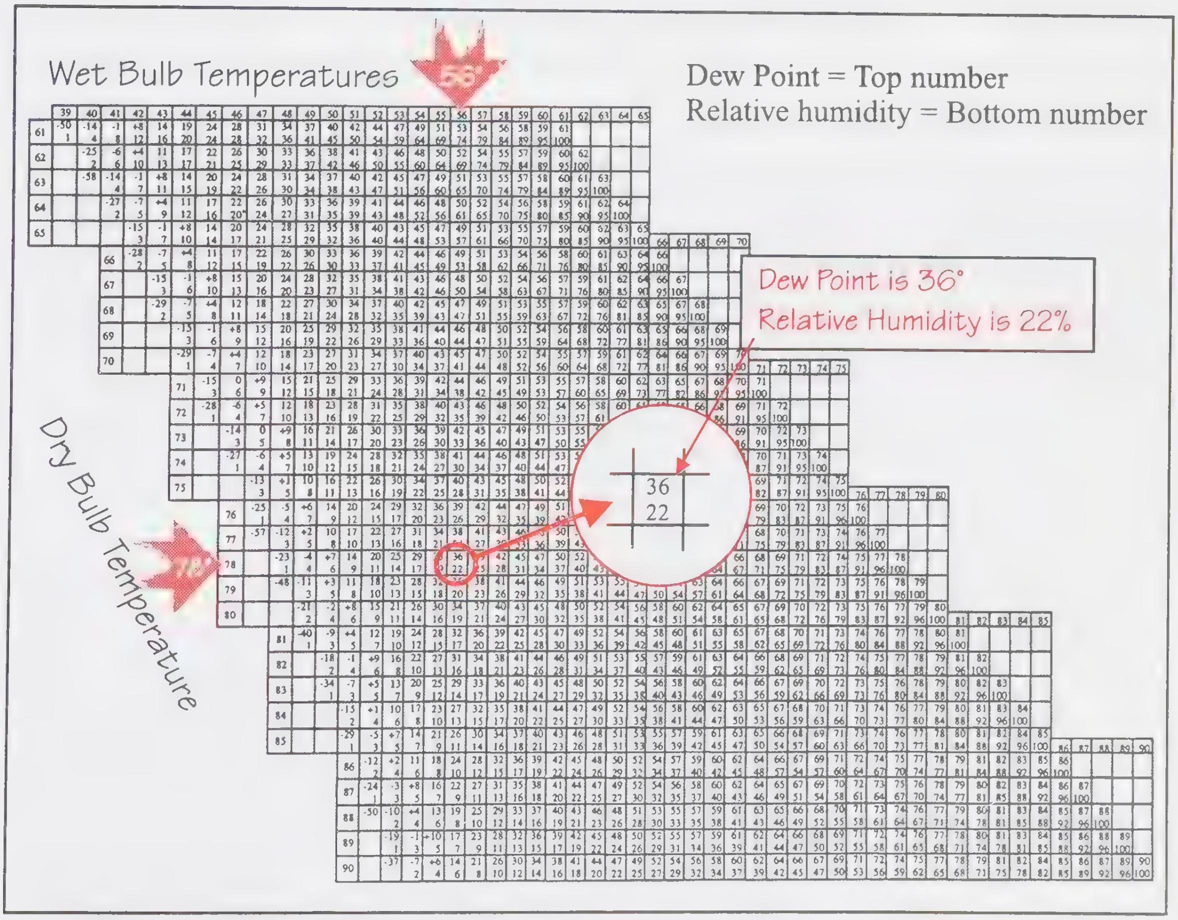

Wet Bulb Temperatures
56°
Dew Point = Top number
Relative humidity = Bottom number
Dew Point is 36°
Relative Humidity is 22%
36
22
Dry Bulb Temperature
78°

Figure 2.16 Charts have been developed to aid in the determination of relative humidity and dew point, based on wet and dry bulb temperatures.

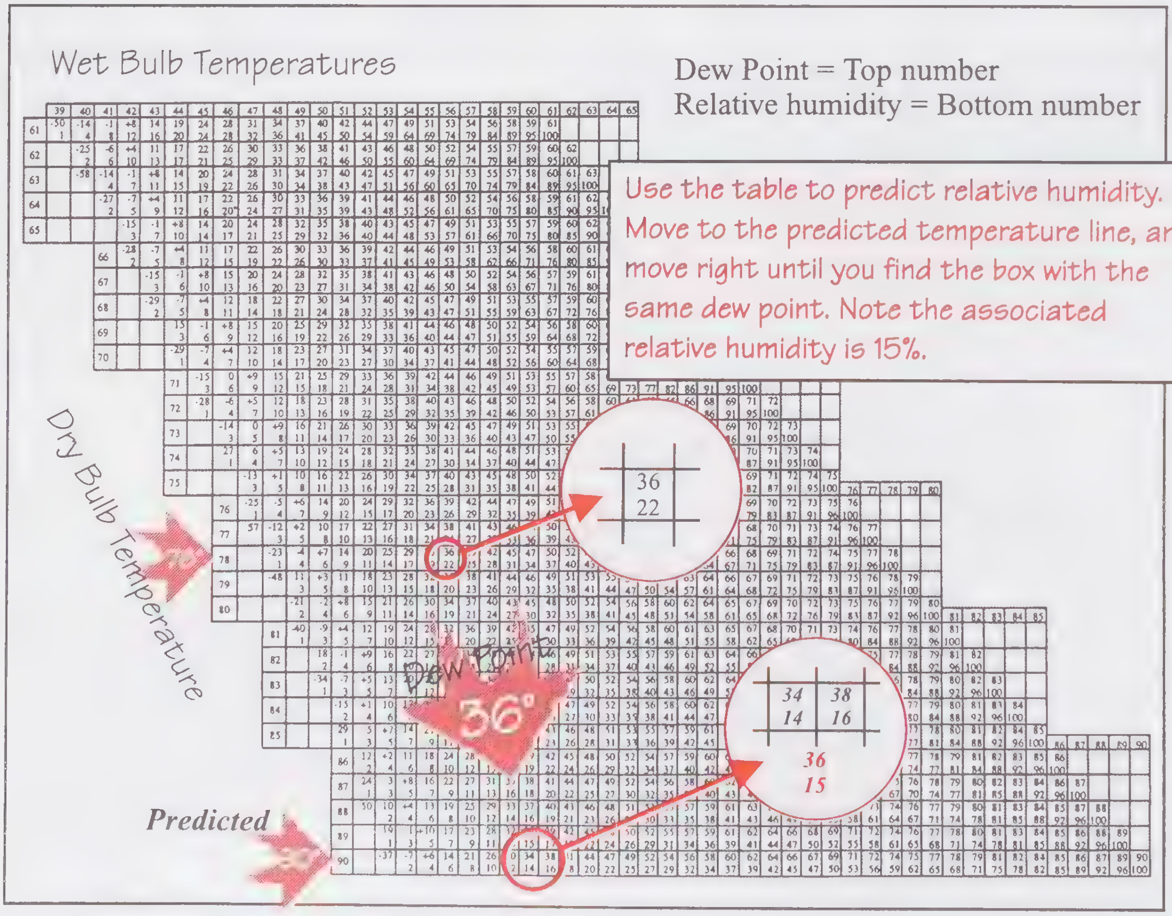
the box represent the dew point (top number) and the relative humidity (lower number). The example shown in Figure 2.17 shows a dry bulb temperature of 78° and wet bulb temperature of 56°. According to the chart, the corresponding dew point is 36°, and the relative humidity is 22%.

Be sure that you use the chart for the appropriate elevation range.

Relative Humidity

Relative humidity is defined as "the ratio of the amount of water vapor actually present in the air compared to the greatest amount possible at the same temperature." The importance of relative humidity, which represents how dry or wet the air actually is, is critical and has a direct impact on fire behavior. Before you

PREDICTING RELATIVE HUMIDITY
(Elevation range 501 to 1900 feet)


Wet Bulb Temperatures
Dry Bulb Temperature
78
Predicted
80
Dew Point
36°
36
22
34
14
38
16
36
15

Dew Point = Top number
Relative humidity = Bottom number

Use the table to predict relative humidity. Move to the predicted temperature line, and move right until you find the box with the same dew point. Note the associated relative humidity is 15%.

Figure 2.17 Use these charts to predict relative humidity.

can understand or predict fire behavior, you need to know the actual and predicted relative humidity.

For every 20° increase in temperature, the relative humidity drops by about ½. Conversely, the relative humidity doubles for every 20° decrease in temperature. As noted in Figures 2.14 and 2.15, knowing this relationship will help you predict how the relative humidity will change during the day or night.

Relative humidity has a direct impact on fire behavior.

If the dew point for an air mass is 45°, and the predicted daytime high temperature is 85°, you can expect an afternoon relative humidity of about 25%. Or, if the nighttime temperature is predicted to be 65°, the predicted nighttime relative humidity will be about 50%.

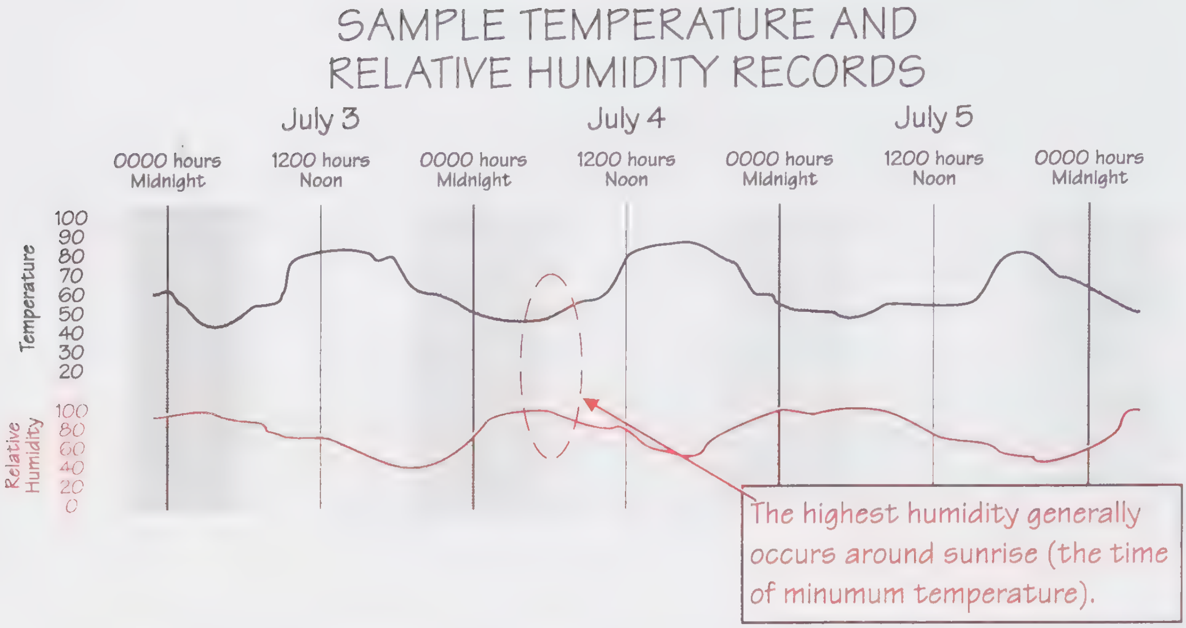
Diurnal Temperature Changes

There are daily or diurnal temperature changes that follow predictable patterns. As the sun rises, so does the temperature. As the temperature rises, relative humidity decreases (Figure 2.18). Humidity drops rapidly after sunrise, and reaches its lowest point about the same time the temperature reaches its maximum. There are usually only minor day-to-day variations in the temperature and relative humidity of the same air mass. But, weather changes and fronts moving through the area may cause dramatic changes in temperature and relative humidity.

Temperature changes follow predictable patterns.

Effects of Terrain, Vegetation, Clouds and Wind on Temperature and Relative Humidity

Terrain, fuel type, and aspect vary from fire to fire, or even on various parts of a large fire. Therefore, temperature and relative humidity, which are influenced by these factors are seldom constant throughout the fire ground. On the other hand, the air mass and its associated water content can normally be considered a constant. So how do all of these various factors impact one another?



The highest humidity generally occurs around sunrise (the time of minumum temperature).

Figure 2.18 This example of the daily changes in temperature and relative humidity is representative of a normal summer day in the Western United States.

Terrain

Aspect and elevation affect both temperature and relative humidity. Studies indicate that southern aspects are generally 5° warmer than northern aspects, primarily due to more direct solar radiation. Fuel cover variations may increase this difference. Since southern aspects are warmer, the relative humidity will be less.

Generally, daytime temperatures decrease with altitude, with a corresponding rise in relative humidity. This trend usually reverses at night. As cooler air flows downslope and collects in the valleys, an inversion develops. In the inversion, colder air with higher relative humidities is layered below warmer, drier air. (Inversion layers will be discussed in greater detail later in this chapter.)

Vegetation

The type, nature and density of vegetation affects temperature and relative humidity by intercepting or reflecting incoming solar radiation. This effect involves both incoming solar radiation during the day and outgoing radiation at night. Low, sparse vegetative cover has much less of an effect than dense, tall vegetation.

In a dense forest with a continuous canopy, the crowns of the trees effectively become the contact surface for solar radiation. Air temperatures within a dense forest are likely to be 5° to 8° cooler than temperatures in nearby cleared areas; the relative humidity may be about 5% to 20% higher. The highest daytime temperatures and lowest relative humidities are found near the crowns of the trees. There will be a gradual decrease in temperature (and rise in relative humidity) as you move closer to the forest floor. The reverse happens at night. A dense forest keeps the outgoing radiation down, and it is warmer under the forest canopy than in open areas nearby.

The highest daytime temperatures and lowest relative humidities are found near the crowns of the trees.

Clouds

Clouds affect temperature and relative humidity in much the same way as vegetative cover. The clouds reflect incoming radiation during the day, decreasing the amount of heat that reaches the earth's surface. A thick cloud cover can lower summer daytime temperatures as much as 15° to 20°, with a corresponding 15% to 20% rise in relative humidity. Clouds also reflect outgoing radiation back to earth at night, maintaining higher temperatures in the evening (Figure 2.19)

Clouds reflect incoming radiation during the day and decrease the amount of heat that reaches the earth's surface.

Wind

Wind affects temperature and relative humidity by mixing air near the ground with air at higher altitudes. By mixing air from different elevations it helps reduce extremes in temperature. If the wind is blowing, daytime temperatures will be cooler with higher relative humidities; nights will be warmer with lower relative humidities.

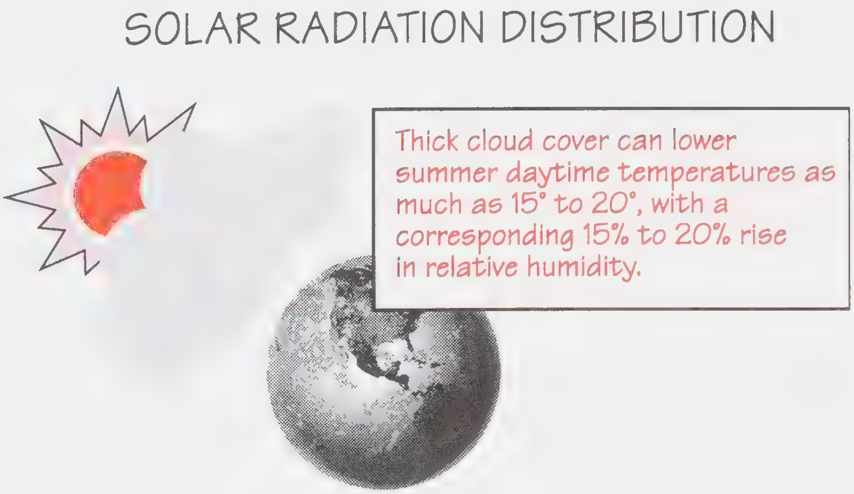

SOLAR RADIATION DISTRIBUTION
Thick cloud cover can lower summer daytime temperatures as much as 15° to 20°, with a corresponding 15% to 20% rise in relative humidity.

Figure 2.19 Cloud cover reflects incoming solar radiation so it does not reach the earth's surface, and holds down the amount of planetary or outgoing radiation that can leave the earth at night.

Atmospheric Stability

Up to this point, we have discussed temperature and its relationship to relative humidity in a two-dimensional way; temperature goes up and relative humidity goes down, or vice versa. But actually, it's more complicated than that. Remember the reference to the Ideal Gas Equation? Atmospheric pressure is also a player in how things change. The temperature we have been discussing is the temperature at ground level. Now we will discuss temperature and winds at higher elevations and their potential impact on fire behavior.

Atmospheric stability is defined as the resistance of the atmosphere to vertical movement.

Atmospheric stability is defined as the resistance of the atmosphere to vertical motion. You've seen satellite images showing cloud movement. This is a two-dimensional view of cloud formations from space. When they show the development of severe thunderstorms during tornado season in the south, you can begin to see and appreciate vertical motion at its best (or worst).

Wind is defined as the horizontal movement of air.

Several factors affect the movement of air masses. They are the earth's rotation, and changes in temperature and pressure. Wind is defined as the horizontal movement of air. It is caused when air from a high-pressure area moves toward an area of low pressure. The vertical movement of air is controlled by the stability of the atmosphere. Depending on the stability of the atmosphere, air can rise, sink, or remain at the same elevation. Stable air resists vertical movement; unstable air encourages it.

Lapse Rates

Lapse rate (or adiabatic lapse rate) is defined as the change in temperature caused by a change in altitude. However, lapse rate is affected both by elevation and the moisture in the air. We already know that temperature decreases as elevation increases. Moisture in the air affects how quickly the temperature changes.

Lapse rate is the change in temperature as an air mass changes elevation.

There are three types of lapse rates: dry, moist and average. The temperature lapse rate of dry air is ±5.5° per 1,000 feet of elevation change. This is a constant, and is called the **dry lapse rate** (Figure 2.20). The **moist lapse rate** is about ±3° per 1,000 feet of elevation change. Remember that when air cools, its relative humidity increases. Once the relative humidity reaches 100%, the rate of cooling decreases. Therefore, when air rises, its temperature changes at the dry lapse rate until it reaches 100% relative humidity or saturation. If it continues to rise, it will cool at the moist lapse rate (Figure 2.21).

The atmosphere may not have a temperature distribution that fits the theoretical dry or moist lapse rate. The **average lapse rate** is about ±3.5° per 1,000 feet of elevation change. Lapse rate temperature changes by time of day, depending on the amount of solar heating and the vertical temperature differences of the air mass. Since you may not know the elevation at which the atmosphere is saturated, you can use the average lapse rate when projecting a temperature above or below an observation site.

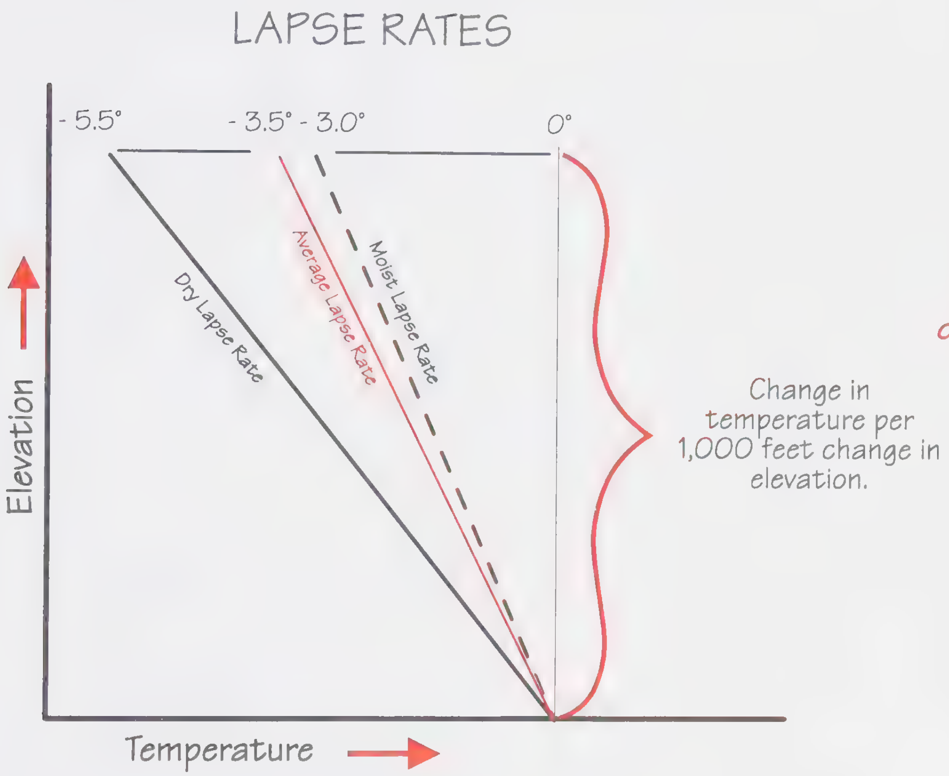

LAPSE RATES
- 5.5°
- 3.5°
- 3.0°
0°
Dry Lapse Rate
Average Lapse Rate
Moist Lapse Rate
Elevation
Change in temperature per 1,000 feet change in elevation.
Temperature

Figure 2.20 Temperature decreases as elevation increases. The moisture in the air has an effect on the rate of temperature change.

Dry air has a lapse rate of ±5.5° per 1,000 feet of elevation change.

Wet air has a lapse rate of ±3.0° per 1,000 feet of elevation change.

The average lapse rate is ±3.5° per 1,000 feet of elevation change.

The lapse rate for moist air is less than that for dry air.

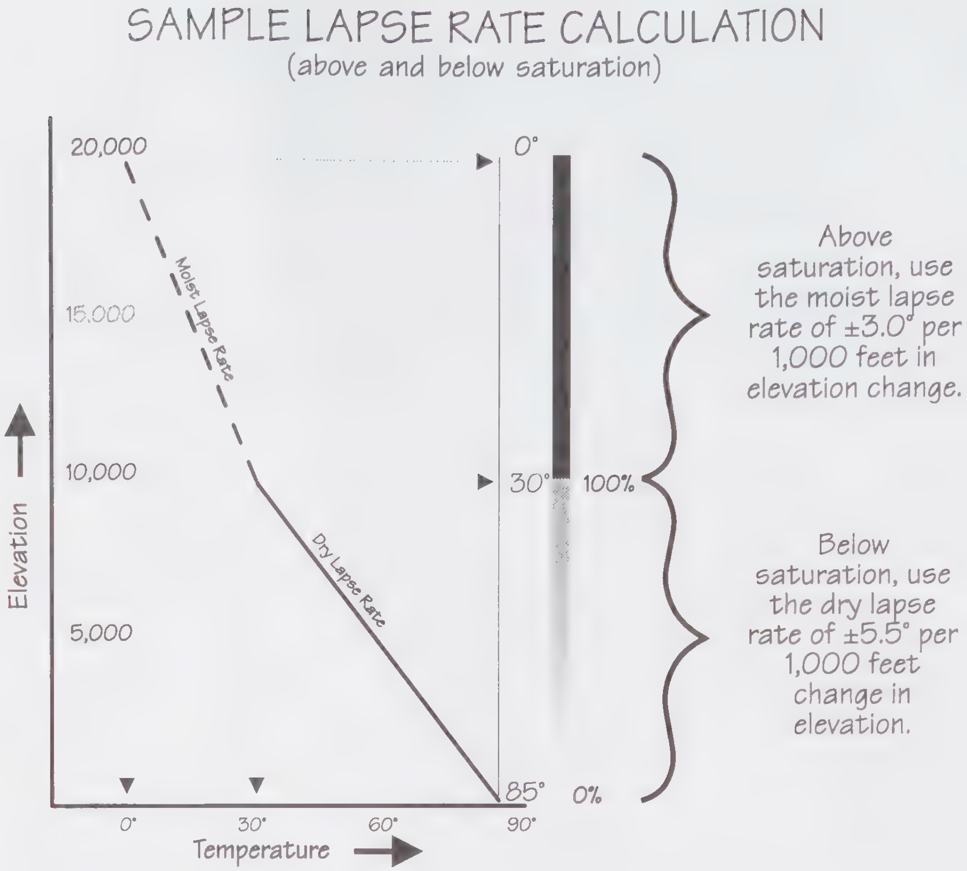

SAMPLE LAPSE RATE CALCULATION
(above and below saturation)
20,000
15,000
10,000
5,000
Elevation
Moist Lapse Rate
Dry Lapse Rate
0°
30°
85°
100%
0%
0°
30°
60°
90°
Temperature
Above saturation, use the moist lapse rate of ±3.0° per 1,000 feet in elevation change.
Below saturation, use the dry lapse rate of ±5.5° per 1,000 feet change in elevation.

Figure 2.21 Once the atmosphere reaches saturation, the moist lapse rate controls cooling.

Figure 2.22 The atmosphere is constantly trying to gain balance.

Stable and Unstable Atmospheric Conditions

In the broad scheme of meteorology, the motions that create weather are an attempt by the atmosphere to gain balance (Figure 2.22), (i.e., "highs" versus "lows," hot air versus cool air, dry air versus moist air). Part of this balancing act involves the vertical movement of air masses. If "things" are in balance, there is little vertical movement of air. This condition is called stable air. If "things" are not in balance (especially the temperature of the air mass), the air is considered unstable. Since hot air rises, if a mass of air is heated, it will rise until it reaches a level where the surrounding air is of the same temperature.

Of course, it is a little more complicated than that. Rising air is cooled at a lapse rate of between 3.0° to 5.5° per 1,000 feet in elevation. So, if we compare the actual lapse rate of the air with the dry adiabatic lapse rate (±5.5°

per 1,000 feet) we can determine whether the air is stable or unstable (Figures 2.23). The lapse rate indicators are as follows:

- If the temperature decrease is GREATER than 5.5° per 1,000 feet, the air is UNSTABLE and there will be vertical movement of air. This is important because unstable conditions have a direct effect on fire behavior. Winds may be more pronounced and spotting may occur over greater distances.
- If the temperature decrease is LESS than 5.5° per 1,000 feet, the air is STABLE and there will be little vertical movement of air. Fire behavior will remain about the same or decrease.
- If the temperature decrease is 5.5° per 1,000 feet, the air is NEUTRAL and there will be little vertical movement of air. This is usually a short-term condition as the air moves between stable and unstable states.

If the air temperature change is greater than 5.5° per 1,000 feet, the air is UNSTABLE.

Remember, stable air resists vertical movement. If an air mass is forced to lift as it goes over a mountain range, it will tend to settle back to its original level on the other side. If the atmosphere is unstable, any air mass that is lifted will tend to rise until

Stable air resists vertical movement.

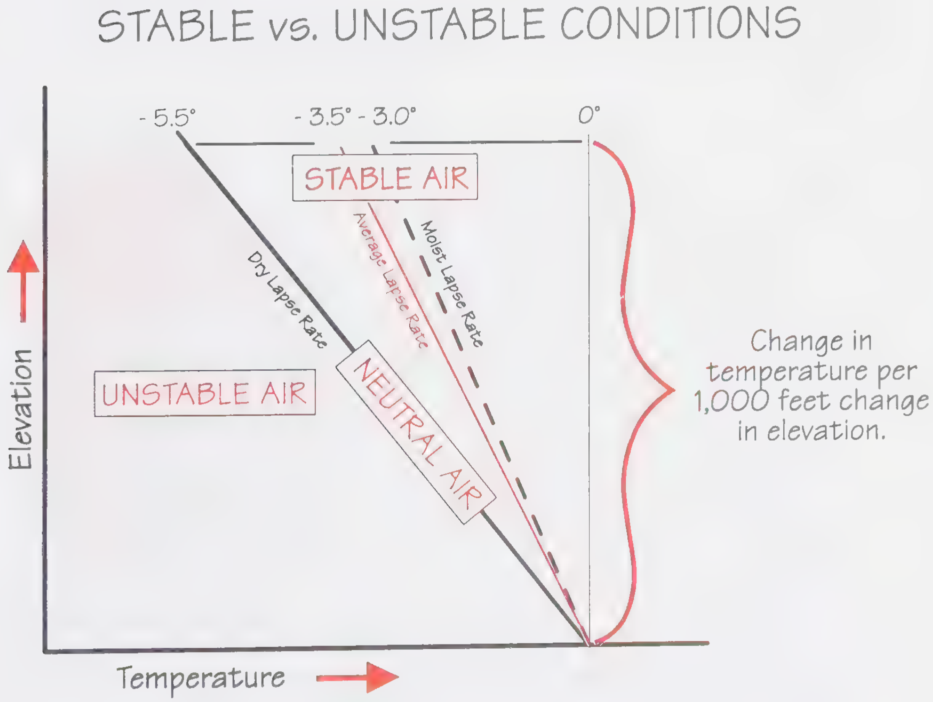

STABLE vs. UNSTABLE CONDITIONS
- 5.5°
- 3.5° - 3.0°
0°
STABLE AIR
Average Lapse Rate
Moist Lapse Rate
Dry Lapse Rate
UNSTABLE AIR
NEUTRAL AIR
Change in temperature per 1,000 feet change in elevation.
Elevation
Temperature

Figure 2.23 The lapse rate is an indicator of whether the air is stable or unstable.

If an air mass is "lifted" going over a mountain range, it will tend to return to its original level.

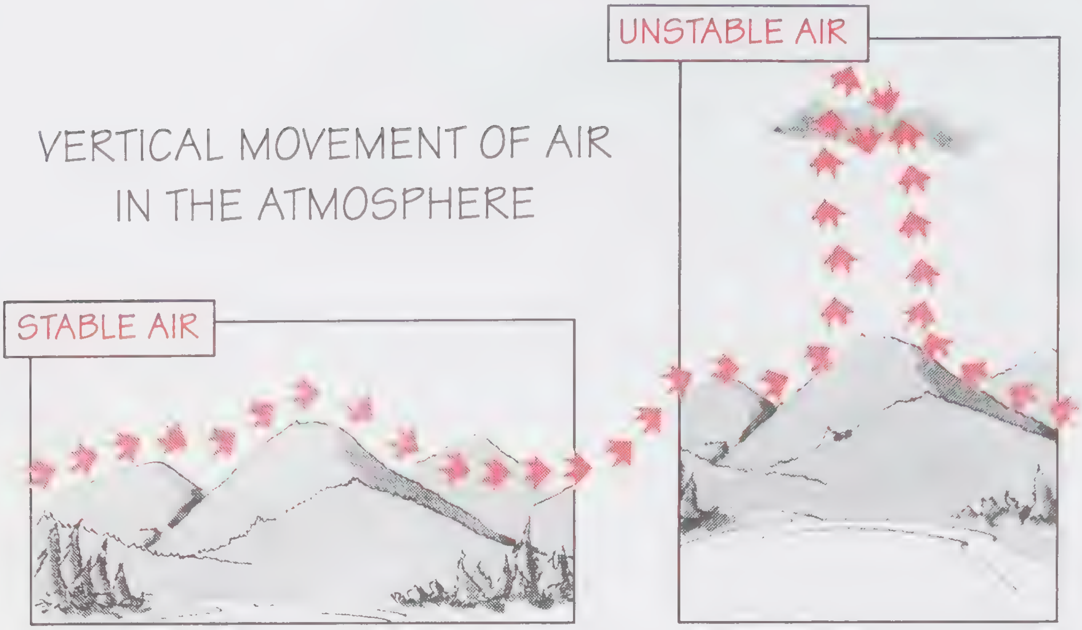


Figure 2.24 Vertical movement of air differs depending on whether the air is stable or unstable.

its temperature decreases (at the rate of 5.5° per 1,000 feet) to equal the air temperature around it (Figure 2.24).

Normally we attribute the changing stability of an air mass to changes in surface heating and cooling. Cooling of the upper air can also cause the atmosphere to become unstable, while warming aloft will create more stable conditions. This is easily understood if you remember that weather changes are driven by the desire of air masses to equalize. If the upper levels of the atmosphere are colder, the difference between the surface air and the air aloft is greater. The warmer air will attempt to rise at a faster rate in order to heat the colder air, thus contributing to unstable conditions.

Stability is changed by surface heating and cooling.

Unstable air can intensify fire behavior by **increasing**:

- The chance of dust devils and firewhirls. Dust devils are common under unstable conditions, and can scatter fire and increase the chance of spot fires. Firewhirls are less common.
- The potential for gusty surface winds. When the air is unstable, strong winds aloft can be brought down toward the surface and may produce strong, gusty surface winds. This can occur very quickly and may catch you by surprise.

Unstable air will intensify fire behavior.

- The height and strength of convection columns. When the atmosphere is unstable, convection columns will rise to greater heights and with greater speed. This causes stronger inward drafts (winds) at the surface. Fire behavior will be affected.
- The chance of spot fires. Tall, well-developed convection columns lift more firebrands, thus increasing the potential for more spotting at longer distances.

Visual Indicators of Atmospheric Stability

Visual indicators are the easiest way to recognize whether the air is stable or unstable. Indicators of stable air are:

- Clouds are in layers with little vertical motion. (Stratus or flat clouds.)
- The smoke column drifts apart after limited rise.
- Poor visibility at lower elevations due to smoke and haze.
- Fog.
- Steady wind.

During stable conditions, the clouds are flat, smoke columns do not rise very high and there is generally poor visibility.

Indicators of unstable air are:

- Clouds grow vertically to great heights. (Cumulus or "building" clouds.)
- Upward and downward currents cause gusty surface winds.
- Good visibility.
- Smoke column rises to great heights.
- Dust devils, firewhirls.

During unstable conditions, the clouds are moving vertically, winds are gusting, there is good visibility. Dust devils develop and smoke columns rise to great heights.

Haines Index

The Haines Index can be used to gauge the relative fire danger. The Haines Index calculates the temperature, dew point and dryness at two levels in the atmosphere and gives a rating between 2 and 6. The drier and more unstable the atmosphere, the higher the Haines Index. The potential for large fire growth is very low when the index is 2 or 3, low when 4, moderate when 5, and high when 6.

If we look at how the Haines Index compares to actual fire history, statistical analysis shows that only 10 percent of large fires occurred when the index was 2 or 3. The Haines Index was usually in this very low range approximately 62 percent of the fire season. In other words, for more than half of the fire season, the chance of a large fire occurring is low. In contrast, 45 percent of

The Haines Index is a measure of air stability. Most large fires occur when the air is unstable.

the large fires occurred when the Haines Index was at 6. This high rating existed about 6 percent of the fire season. In other words, nearly half of the large fires started during periods when the temperature, dew point, and moisture created the most unfavorable conditions.

A Haines Index of 6 (the highest rating) occurs less than 10% of the fire season.

The Haines Index is not something you will be calculating in the field. However, some fire weather forecasters are including it in their forecasts.

Inversion Layers and Thermal Belts

An inversion layer is a layer of very stable air where, contrary to normal behavior, the **temperature rises as the altitude increases**. Temperatures in an inversion layer may increase as much as 15° per 1,000 feet in altitude. A thermal belt is the "warm area" on a mountain slope associated with an inversion layer.

In an inversion layer the temperature RISES as the altitude increases.

An inversion layer acts as a lid or blanket over cooler air. Air rises when warm air is surrounded by cooler air. Cool air will not rise through the warm air. Because of this, inversion layers severely limit vertical motion in the atmosphere. Smoke generated by a fire will rise to the inversion layer (or to a point where temperatures equalize), then flatten out and spread horizontally because it has lost its ability to rise. There are three types of inversion layers. They are categorized by how they are formed and whether they are located at the earth's surface or aloft.

The presence of an inversion layer indicates that the air is very stable.

Nighttime Inversion Layers

Nighttime (or radiation) inversion layers are the most common type. They are created when heat is radiated away from the earth's surface at night, and the air is subsequently cooled by cold land masses. This occurs mainly in the inland valleys and mountainous areas. Conduction is also a factor in the formation of nighttime inversion layers. Air at the earth's surface cools faster than it does at higher levels (air is a poor conductor of heat), thus creating a condition where there is cooler air below warmer air. The layer closest to the earth deepens as the night progresses. This is why the inversion layer is thickest in the early morning

Nighttime inversions occur mainly in the mountains.

hours. During this time, the air is very stable because the different air temperatures of the two layers will not support vertical movement (Figure 2.25).

Inversion layers are normally "thickest" during the early morning hours.

Inversion layers are deeper and more pronounced in mountainous areas and valleys, because as the air cools on the slopes, it "flows" into the valley below. This helps deepen even further the thickness of the "inverted air mass." Since cloud cover reduces the amount of radiated heat, and wind mixes and moves air, inversion layers are shallower on cloudy, windy nights. Stable air conditions can develop under cloudy skies, but their degree of development is less than with clear or fair skies. A good guideline to remember is that cooling from below promotes stable air, while heating from below promotes unstable air (Figure 2.26).

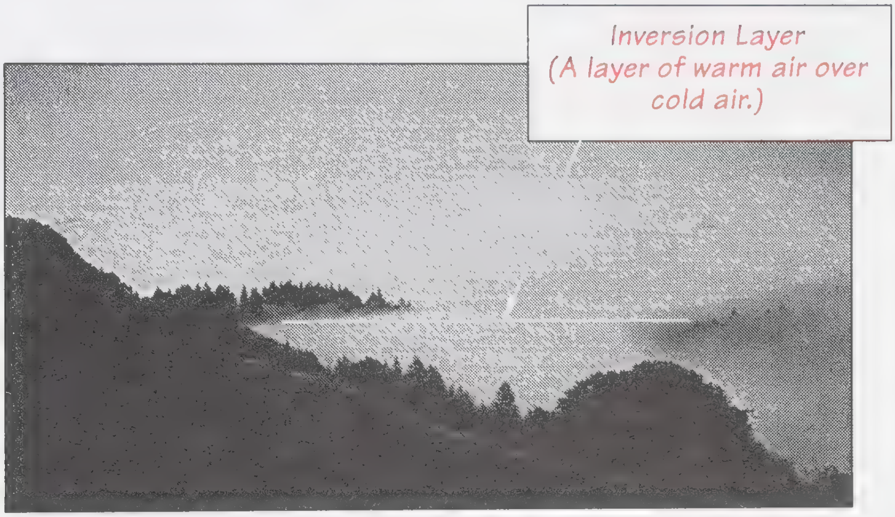


Figure 2.25 Inversion layers form when cooling of the earth at night results in cooler air underneath warmer air. Inversion layers are thickest in the early morning.

Cooling from below promotes stable air; heating from below promotes unstable air.

Inversion layers usually begin to weaken after sunrise when the sun begins to warm the earth's surface. As the earth's surface warms, so does the air closest to the surface. Both conduction and convection take place. Once the air on the surface becomes warmer than the air above it, it will begin to rise. Inversions usually break down before noon. When an inversion layer breaks down allowing more vertical air movement, fire behavior increases. This change may be either gradual or sudden. Winds may

Inversion layers begin to weaken when the sun comes up.

increase while the relative humidity decreases.

If you're fighting fire in an area where inversion layers are present, you should monitor the weather on at least an hourly basis so that you can detect potential changes in the weather factors and be prepared to respond to associated changes in fire behavior. You don't want to be surprised by an event that is very predictable (Figure 2.27).

If an inversion layer is present, monitor the weather so that you can tell when it starts to lift.

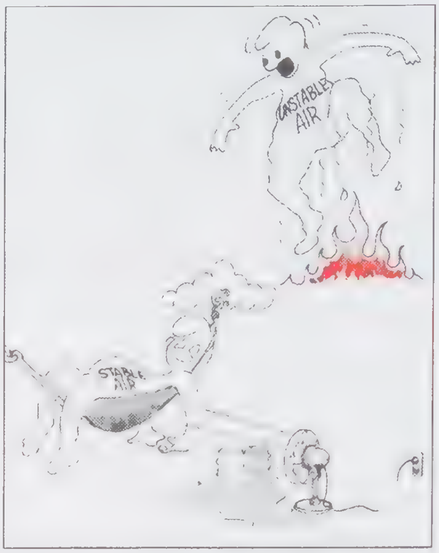


Figure 2.26 Cooling from below promotes stable air; heating from below promotes unstable air.

Marine Inversion Layers

Marine inversion layers have their roots in the ocean, thus they are found in coastal areas. Cool, moist air from the ocean moves over nearby low-lying lands. This layer of air will vary in depth, from several hundred to several thousand feet. The thicker the layer, the further inland it will invade. Because the marine layer is made up of cool, moist air, it moves in under warmer, drier and relatively unstable air. This intrusion of cool, moist air may persist during the day, but is generally strongest and most noticeable at night. Fog

The presence of fog indicates stable air.

Figure 2.27 The breakup of an inversion layer can be predicted.

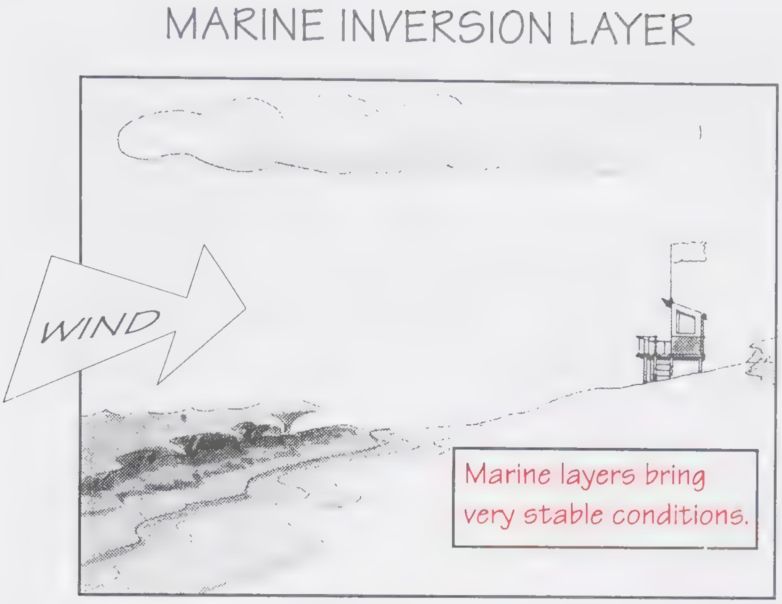

MARINE INVERSION LAYER
WIND
Marine layers bring very stable conditions.

Figure 2.28 Marine inversion layers bring fog and very stable conditions with them.

Cool, moist air reduces the level of fire behavior. It will also impact any "burning" your plan may call for.

and stratus clouds often form in the marine layer at night, and move inland into coastal basins and valleys. Fog usually forms if the marine layer is shallow and low stratus clouds if the layer is deep (Figure 2.28).

The intrusion of a marine layer is usually helpful during firefighting. The cool, moist air reduces fire behavior. However, a marine layer can cause a problem when firefighters are trying to burn out an area at night, because this same cool, moist air will interfere with (or prevent) a good, clean burn. Another time that marine air can cause real problems, is when a Santana or foehn wind is degrading. This degradation occurs over several hours. During this time, you may have what are called "battling winds," that are pushing back and forth over an area. This can cause real havoc for firefighters because there can be relatively strong wind shifts (up to 180° in direction) every few minutes (Figure 2.29).

"Battling winds" should be of concern on the fireline. Winds can quickly change direction.

Subsidence Inversion Layers

Subsidence layering is a slow sinking motion of a high level air mass over a broad area. It is associated with the presence of a high-pressure system. Once again, this is a slow process, and only occurs when the high-pressure system is stationary for several days. This situation usually occurs during the summer and fall months (Figure 2.30).

Gee, Chief...
Is there a safe plan of attack with these "battling winds?"
FIRE

Figure 2.29 Battling winds can be of real concern to the firefighter.

As this air mass sinks it compresses, becomes warmer, and the relative humidity falls dramatically. The inversion layer will affect peaks and ridges first. If it persists, it could have a significant impact on fire behavior. Subsidence inversion layers can hold smoke in a wide area for days and even weeks. They also prevent nighttime relative humidity recovery. Therefore, fuels in the area will become much drier than normal.

Another effect of subsidence can be foehn winds. Foehn winds occur on the lee slopes of prominent mountain ranges when stable air pours over ridges and through canyons, creating very strong, dry winds (Figure 2.31).

Thermal Belts

A thermal belt is that area of a mountain slope where a nighttime inversion layer "bathes" it with warmer and drier air. This area on the mountain will experience the least amount of temperature swing between nighttime lows and afternoon highs. The temperature above and below the thermal belt will be cooler than the area within the thermal belt. The thickness of a thermal belt is controlled by the depth of the associated inversion layer (Figure 2.32).

Knowing the location of the thermal belt is important. Fire behavior in this area will be much more intense.

Knowing the location of the thermal belt is important to you as a firefighter. The fire behavior in this area will be much more intense than in areas above or below it. This difference in fire behavior is normally caused by warmer temperatures and lower relative humidities. Since inversion layers are associated with stable air, the winds in thermal belts are normally light and steady.

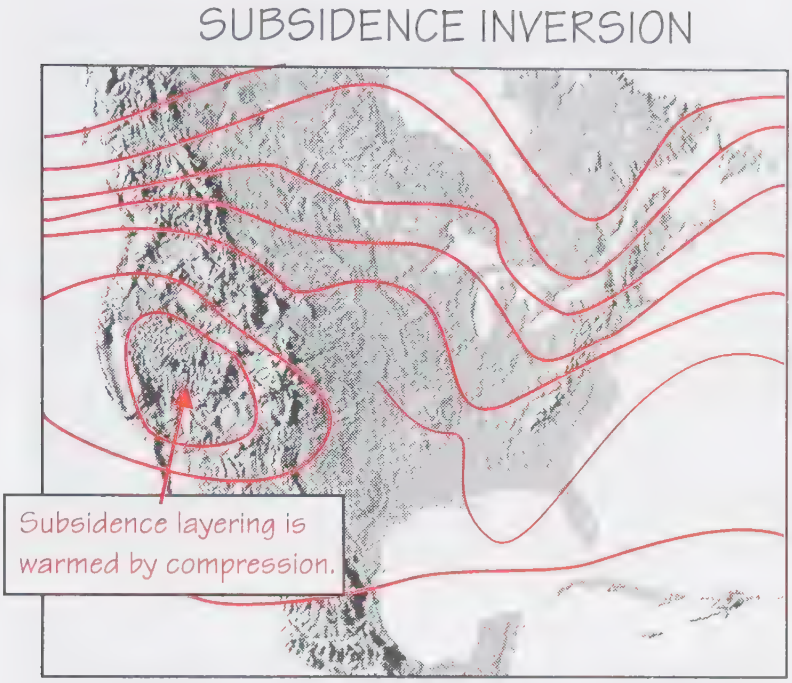


Figure 2.30 Subsidence inversion layers are formed over wide areas when a high-pressure system becomes stationary.

Subsidence inversions are slow to develop, but may persist for days and even weeks.

Clouds

Clouds can predict fire behavior!

Clouds are the result of weather factors that may also have an effect on fire behavior. As a fire officer, you should look up and around to assess the clouds in the area. They may give you a clue as to why something is happening, or what is about to happen. Read the clouds as you would a contour map.

Clouds are made up of water and/or ice particles in the atmosphere, and result from the condensation of water vapor in the air. Most clouds are formed when a rising air mass cools to the point of saturation. Low level clouds are formed when warm, moist air is cooled to the dew point (or saturation) by passing over cooler air. This cooling takes place near the ground. However, if the winds are strong enough, the mixing of air masses may produce clouds hundreds or thousands of feet above the

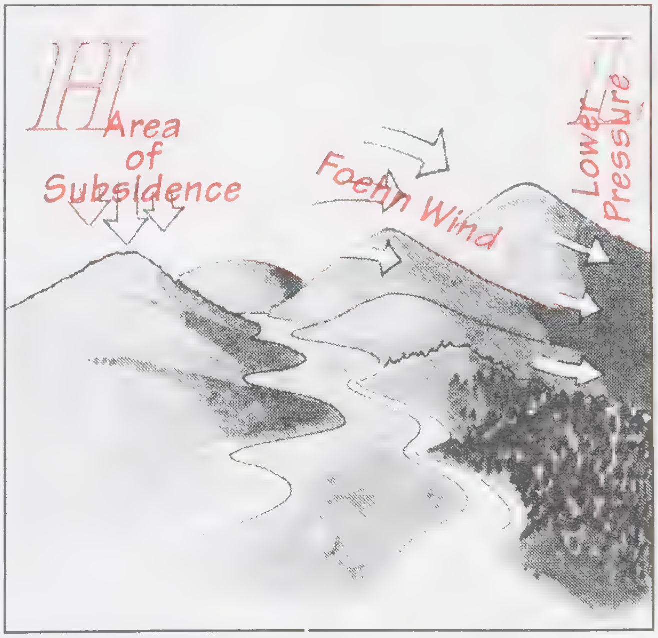


Figure 2.31 Foehn or gravity winds are caused by areas of subsidence.

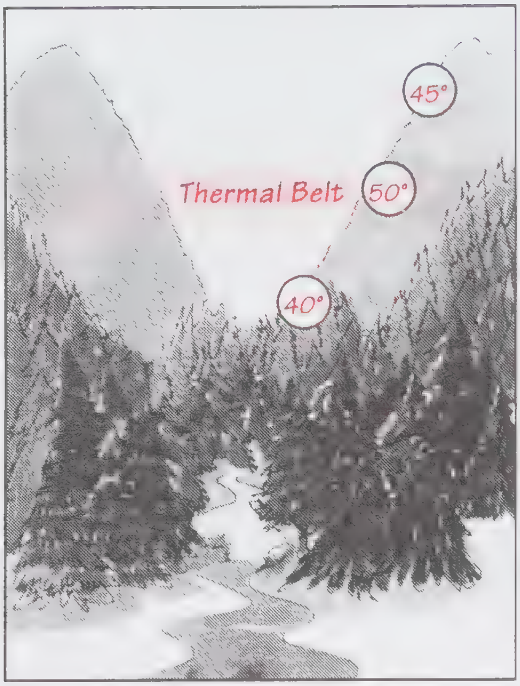


Figure 2.32 The existence of a thermal belt will affect fire behavior.

surface. Clouds can also be formed by the addition of water vapor to an air mass. This usually occurs as dry air passes over warm water and water vapor is evaporated into the air. Rain falling through a cool air layer will also add moisture to the air mass.

Clouds are classified by their structure and their height in the atmosphere. Cirro clouds (cirrus, cirrocumulus, and cirrostratus) are high clouds with bases above 20,000 feet. Alto clouds (altostratus, altocumulus, and nimbostratus) are middle level clouds with bases between 6,500 to 20,000 feet. Strato clouds (stratus and stratocumulus) are low level clouds with bases at or below 6,500 feet. Cumulus and cumulonimbus clouds are vertically developed clouds which may have bases between 1,500 to 10,000 feet. Fog, on the other hand, is essentially a cloud that touches the surface of the ground.

Cloud Identification

There are many types of clouds. However, there are six cloud formations that are especially important for the firefighter to know and understand. These are "indicator" clouds, which will help you predict future fire behavior.

Cumulonimbus or thunderstorm clouds - Cumulonimbus clouds begin as small, fair-weather cumulus clouds, that grow as the atmosphere becomes more unstable. These cloud formations can occur individually as "air mass thunderstorms" or as a "line or wall" of thunderstorms associated with a cold front. Thunderstorms may produce strong, gusty winds, sometimes gusting to as much as 60 miles per hour. Thunderstorms can produce a very devastating impact on a fire. By the time you notice them, they usually have already begun to influence fire behavior. Therefore, you must heed and monitor fire weather forecasts warning of impending thunderstorm activity (Figure 2.33).

Thunderstorms may produce strong, gusty winds, sometimes gusting to 60 miles per hour.

Cirrostratus clouds - These are very high, wispy clouds that frequently precede a warm front. These clouds are formed when the tops of thunderstorms are blown off by strong winds. They may be carried for 500 miles or more. These cloud formations

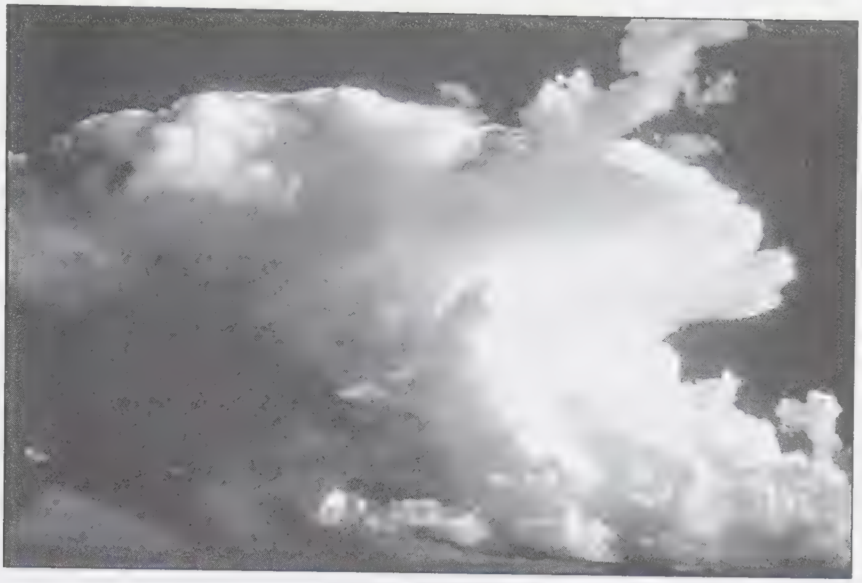


Figure 2.33 Cumulonimbus clouds.

Thunderstorms bring windy conditions.

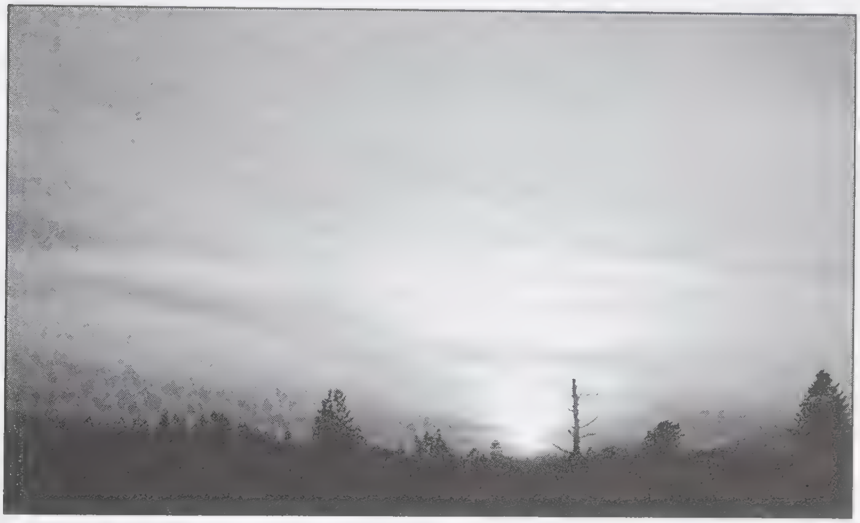


Figure 2.34 Cirrostratus clouds.

Cirrostratus clouds may indicate rain in a couple of days.

thicken and lower as they approach. They indicate that rain is possible within the next day or two (Figure 2.34).

Altocumulus castellanus clouds - These are mid-level clouds that form turrets or "little towers," usually arranged in lines. They indicate instability and increased moisture. When seen in the morning, these clouds are a strong indicator that thunderstorms are possible later in the day (Figure 2.35).

Altocumulus floccus clouds - These clouds can be identified by their white or gray colored scattered "tufts," with rounded and slightly bulging upper parts. These clouds resemble very small ragged cumulus, and are often accompanied by trails of virga (rain which doesn't reach the ground) from their bases. Like the altocumulus castellanus clouds, they are an indicator of instability, increased moisture and potential thunderstorm activity (Figure 2.36).

Altocumulus castellanus clouds indicate there may be thunderstorms in the afternoon.

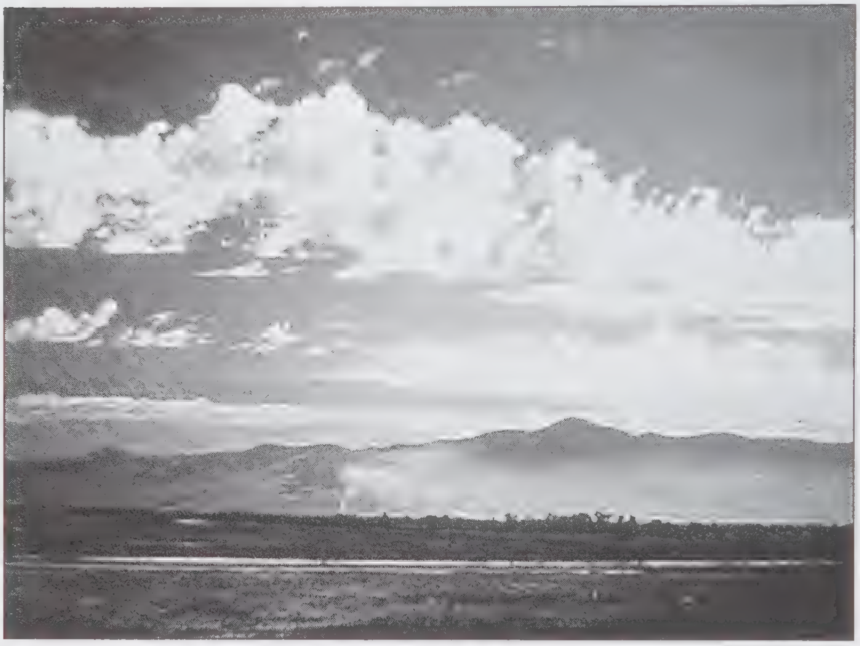


Figure 2.35 Altocumulus castellanus clouds.

Altocumulus floccus clouds indicate unstable conditions.

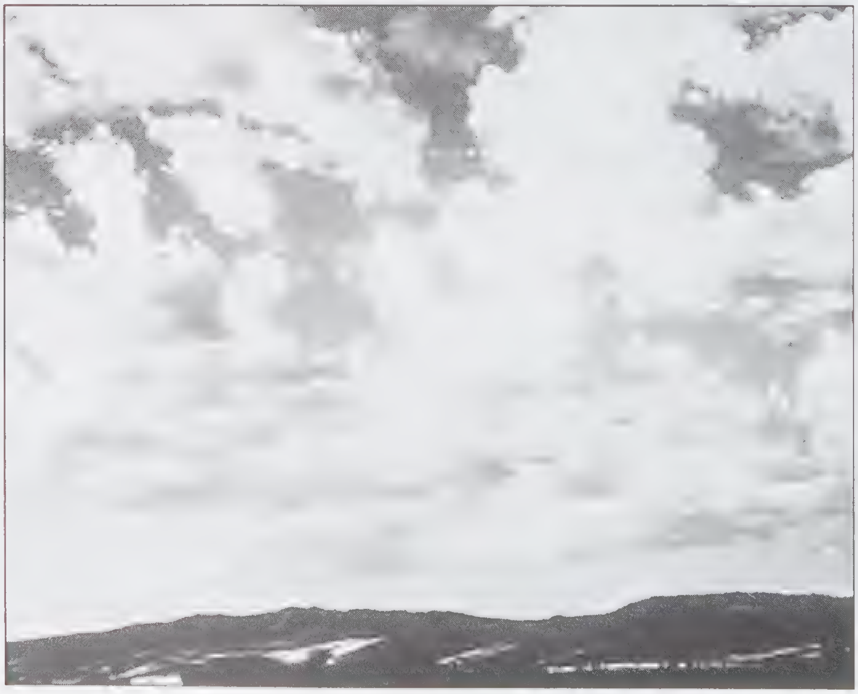


Figure 2.36 Altocumulus floccus clouds.

Altocumulus lenticularus clouds - These "lens-shaped" clouds are formed as strong, mid-level winds cross over the top of north/south oriented mountain ranges. They are usually stationary, and positioned over the lee side of a mountain range. Altocumulus lenticularus clouds are indicative of high wind speeds at the altitudes at which they occur. However, these winds can descend or "surface," producing strong ground level winds that can cause long-range spotting. A visual indicator of the possibility that these winds may surface is a sheared smoke column (Figure 2.37).

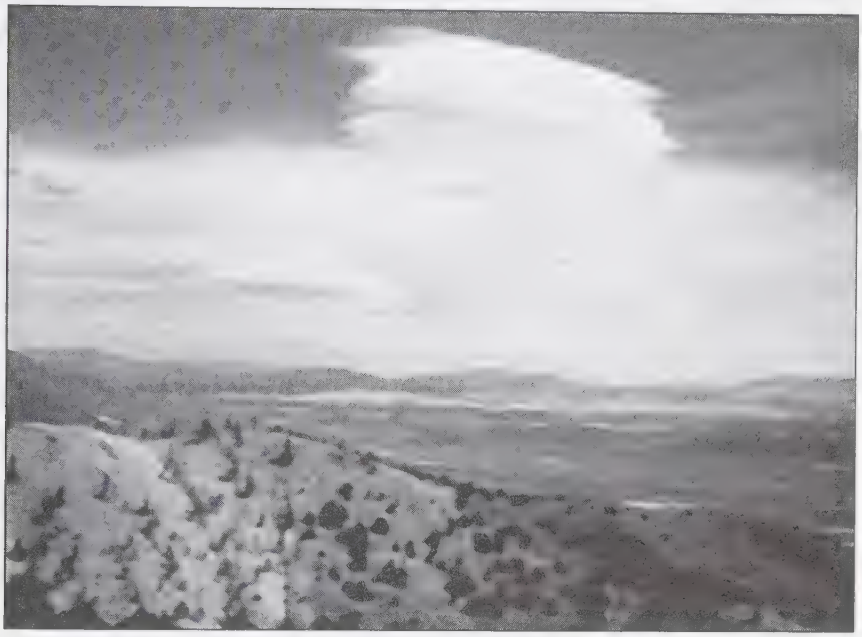


Figure 2.37 Altocumulus lenticularus clouds.

Lenticular clouds indicate strong winds aloft.

Stratus clouds - These occur as a single, gray, fairly uniform and featureless layer of low-level clouds. Sometimes they are dark and threatening, although at most, they only produce a drizzle or light rain. Stratus clouds are an indicator of stable air (Figure 2.38).

Thunderstorm Development

A thunderstorm is defined as "a storm accompanied by lightning and thunder." Thunderstorms also bring with them strong gusty winds that may have a serious impact on fire behavior. You can usually detect a developing thunderstorm by recognizing characteristic cloud formations.

A thunderstorm in your area WILL impact your fire! Be careful.

Stratus clouds indicate stable conditions.

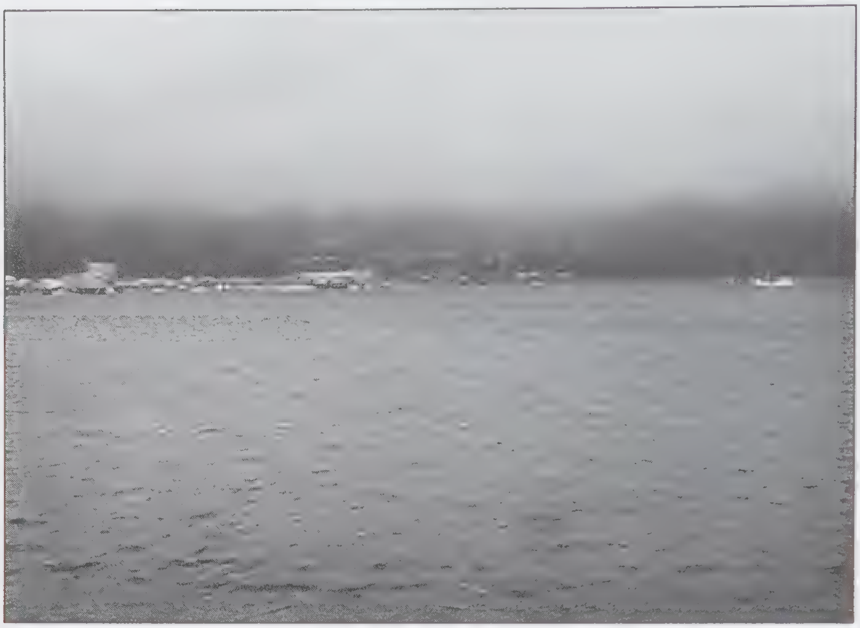


Figure 2.38 Stratus clouds.

There are four ways thunderstorms are formed. These are classified as lifting processes. Each of the processes differ in what causes air to rise and develop into a potential thunderstorm. Most of the time several of these lifting forces are involved with the formation of a thunderstorm.

Thermal lifting occurs when air is heated. If there is adequate moisture in this rising air mass, it will form a cloud when it reaches saturation. Thermal lifting is most prevalent during the summer and occurs in areas of flat terrain being heated by solar radiation. It can also occur when the air is heated by a large wildland fire. The formation of cumulus clouds over a fire is an indication of extreme fire behavior and the potential for a thunderstorm (Figure 2.39).

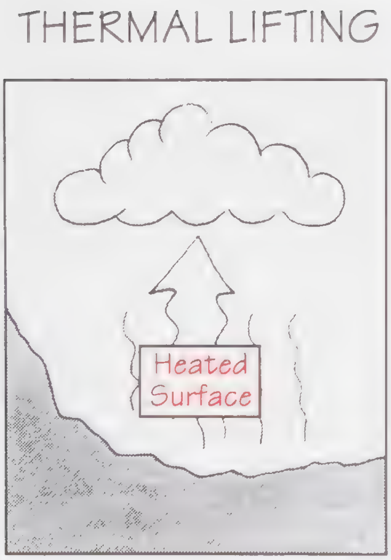


Figure 2.39 Thermal lifting is the result of heat generated by solar radiation or a large wildland fire.

Orographic lifting occurs when an air mass that is moving horizontally encounters a moun-

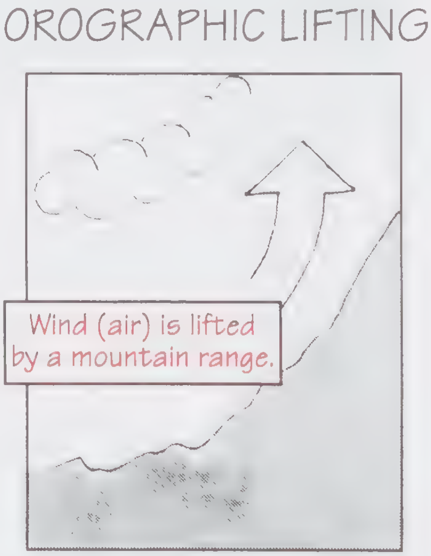


Figure 2.40 Orographic lifting is the result of an air mass being lifted by a mountain range.

tain range and is forced upward. The air mass cools as it moves upward, and forms a cloud when it reaches saturation. Orographic and thermal lifting may work together in the formation of a thunderstorm (Figure 2.40).

Frontal lifting occurs when a cold front moves under a warmer air mass and forces it upward. Again, if the air is forced high enough, a cloud will form when the air becomes saturated (Figure 2.41).

FRONTAL LIFTING

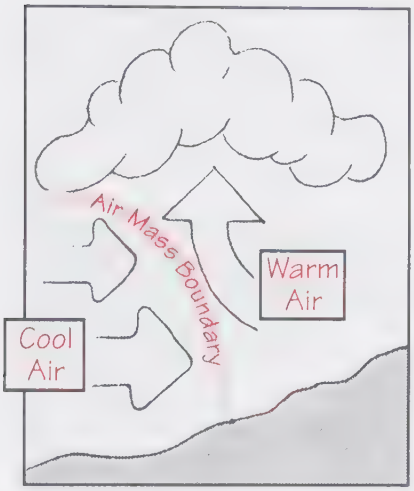


Figure 2.41 Frontal lifting occurs when a cold front moves under a warmer air mass.

Convergence lifting is always associated with a low-pressure system. As the atmosphere attempts to equalize, air moves from high-pressure zones toward low-pressure zones. If more air moves (horizontally) into a low-pressure area than moves out, the "excess air" is forced upward. This lifting cools the rising air and when it reaches saturation a cloud is formed. Convergence lifting is the reason that low-pressure systems usually include cloudy conditions (Figure 2.42).

Most of the time more than one of the "lifting mechanisms" are involved in the development of a thunderstorm.

CONVERGENCE LIFTING

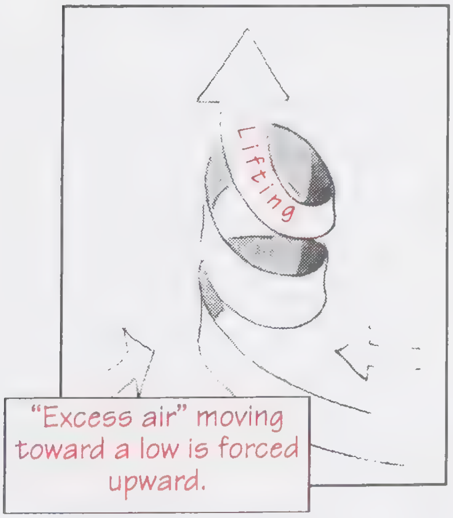


Figure 2.42 Convergence lifting is associated with low pressure fronts.

Stages of a Thunderstorm

There are three stages in the life of a thunderstorm. They are the cumulus or forming stage, the mature stage, and the decaying or dissipating stage. Each of these stages have different weather phenomenon associated with them, and each may affect fire behavior in different ways.

Never underestimate the impact a nearby thunderstorm may have on your fire. They are "killers!"

Cumulus stage - This stage begins with the formation of a cumulus cloud on the top of a rising air mass. As the cloud grows taller, it begins to look like a head of cauliflower. During this stage of development there are strong indraft winds moving into the base of the cloud. This action may increase surface winds. As updrafts in the cloud increase, wind may begin to change and blow in the direction of the developing thunderstorm (Figure 2.43).

As the thunderstorm develops, strong indraft winds move into the base of the cloud.

Mature stage - The mature stage of a thunderstorm is the most active and dynamic. As the cloud develops, rain or virga begins to fall from its base. As the rain falls, it causes air to drop with it; this is the beginning of the cloud downdraft. The cloud now has downdrafts and updrafts associated with it. The updraft is warmer than the surrounding air; the downdraft cooler. The cloud develops an anvil shaped top, and lightning begins. At this point, the cumulonimbus cloud has developed and a thunderstorm is produced. The downdrafts that reach the ground are cool and gusty. These winds can extend up to 10 miles from the thunderstorm, and reach 20 to 35 miles per hour, with gusts to 60 miles per hour. You can appreciate what winds of this strength can do to the fire behavior on a nearby fire.

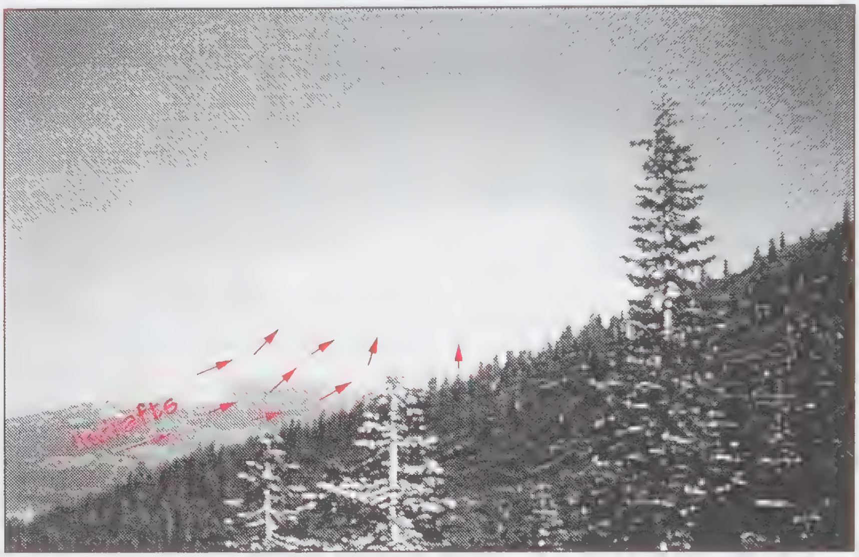


Figure 2.43 The start of a thunderstorm; indrafts may affect fire behavior.

When a thunderstorm is "mature" it has an anvil shaped top.

Dissipating stage - This stage starts when the thermal lifting weakens, the updrafting slows, and the source of moisture and energy ends. The thunderstorm now generates only downdrafts and the rain slows and eventually stops. The temperature difference between the cloud and the surrounding air equalizes and the cloud dissipates.

When a thunderstorm begins to dissipate, downdrafts develop.

Winds

As noted previously, wind is defined as the horizontal movement of air, and is one of the most important of the weather factors. More often than not, wind is involved in fatal or near-fatal wildland fires. General winds are named for the direction they are coming from. A north wind is coming from the north, south wind from the south, etc. You care for whence the wind comes, for once it gets to you, you care not whence it goes!

Winds are named for where they COME FROM, not for where they are going.

There are several winds that you should be familiar with. They are:

- **General winds** which affect large areas. These are the winds that are reported in daily weather forecasts.
- **Local winds** which are produced by features of the local terrain.
- **Surface winds** which are those that are normally measured at 20 feet above the ground.
- **Midflame winds** which occur at the midpoint of flame height, and **have the greatest effect on the direction a fire will burn** (Figure 2.44).

Surface winds are measured at 20 feet above the ground.

Wind affects wildland fires in several important ways:

- By moving moisture-laden air that may reduce fire behavior.
- By hastening the drying of wildland fuels.
- By increasing the supply of oxygen, thus aiding combustion.
- By carrying burning embers to new fuels and increasing fire spread.
- By bending the flames closer to unburned fuels, preheating and igniting them.
- By determining the direction of spread (when wind is the dominating factor).

Midflame winds have the greatest effect on the direction a fire will burn.

Don't ever forget to factor the predicted winds into your plans. Many firefighters have died because of such an oversight.

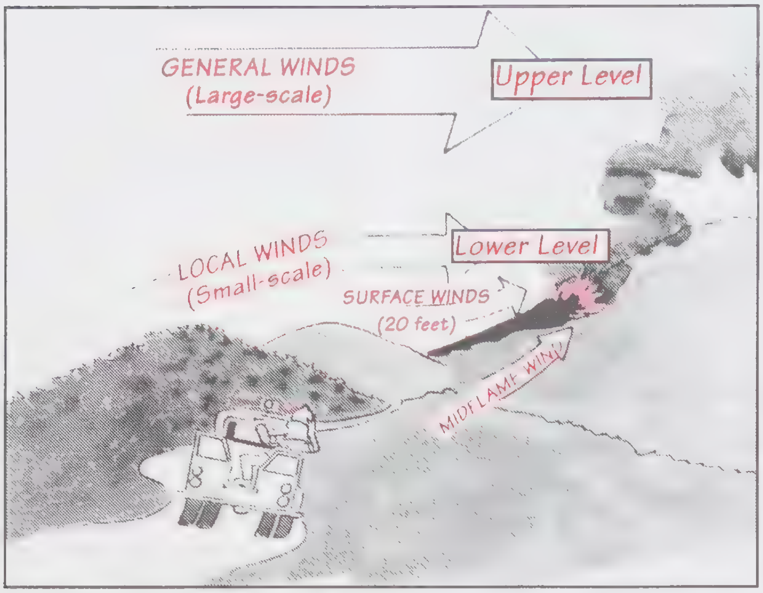

GENERAL WINDS
(Large-scale)
Upper Level
Lower Level
LOCAL WINDS
(Small-scale)
SURFACE WINDS
(20 feet)
MIDFLAME WIND

Figure 2.44 The types of winds fire officers must understand.

High- and Low-Pressure Systems

Winds have their origin on the sun. They're the result of solar radiation heating the earth's surface. The earth does not heat in a uniform way. This uneven heating creates atmospheric pressure differences called pressure gradients.

The atmosphere is constantly trying to equalize and come to a balance. Winds are produced as air from a high-pressure area moves toward a low-pressure area. The greater the difference between the pressure areas, the stronger the winds can be. This process occurs over large areas; sometimes the distance between the highs and lows is hundreds of miles (Figure 2.45).

The atmosphere is constantly trying to balance between the high and low-pressure areas.

LARGE SCALE PRESSURE SYSTEMS AND FRONTS

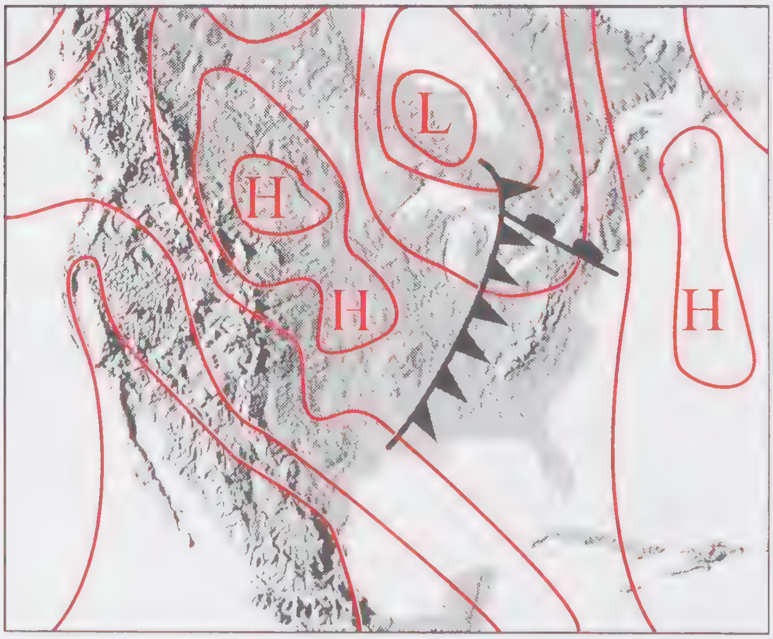


Figure 2.45 Highs and lows are a product of uneven heating of the earth's surface.

There are many forces of nature that contribute to the circulation of air masses around the earth. Some of these factors include the rotation of the earth, gravity, and differences in solar heating. As air near the equator rises, air from the cooler polar regions moves into the void. This process develops a natural high pressure over the poles and low-pressure areas near the equator. Combine this action with the rotation of the earth, and you get an atmosphere that is in a state of constant motion.

The force of the earth's rotation on the moving air causes the air (wind) to rotate in a counterclockwise direction north of the equator, and clockwise south of the equator. This rotation of the air (wind) is called the **Coriolis force** or effect. This motion also causes the development of regional wind belts. These wind belts in the Northern Hemisphere have several names: the Doldrums, near the equator; the Northeast Trades, between the equator and latitude 30° north; the Prevailing Westerlies from latitude 30° north to near 60° north; and the Polar Easterlies north of 60° north (Figure 2.46).

As the warm air near the equator rises, air from the cooler polar regions moves into the void.

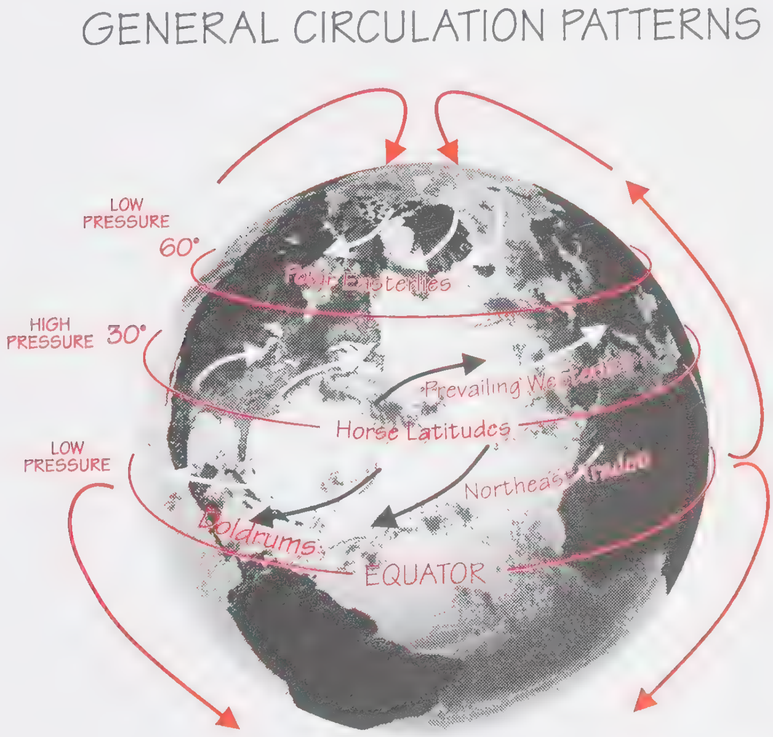

GENERAL CIRCULATION PATTERNS
LOW PRESSURE
60°
Polar Easterlies
HIGH PRESSURE
30°
Prevailing Westerlies
Horse Latitudes
LOW PRESSURE
Northeast Trades
Doldrums
EQUATOR

Figure 2.46 General wind circulation created by the rotation of the earth.

At some latitudes, the air tends to "pile up" and become belts of high-pressure. These belts or cells are not uniform nor are they stationary. General weather factors are dependent on the location and movement of these high-pressure cells. The maps used to display and track the various pressure cells are similar to a contour map. Points of equal atmospheric pressure are shown with a line, similar to a contour line. These pressure lines are called isobars. The number and closeness of isobars gives an indication of the **pressure gradient**, or difference in atmospheric pressure between the highs and lows. **Wind speed is determined by the pressure gradient. Wind direction is determined by the relationship (locations) of the highs to the lows.**

Wind speed is determined by the difference in pressure areas. The greater the difference in pressures, the stronger the wind.

The pressure zones (the highs and lows) tend to move from west to east in the United States. They are pushed by the upper level westerlies or jet stream winds. Air moves around a high-pressure cell in a clockwise direction and counterclockwise around a low-pressure cell. This has a direct effect on the winds that occur at the surface. A good rule of thumb: if you have your back to the general wind, low-pressure is to your left and high pressure is to your right.

If you have your back to the general wind, low-pressure is to your left and high-pressure is to your right.

You can also use weather maps to plot the location of cold and warm air masses. These air masses are delineated by a line called a front. When cold air is displacing warm air, this is a **cold front**. When warm air is displacing cooler air, this is a **warm front**. When a warm air mass rides up and over a colder air mass, this area is called an **occluded front.**

When warm air is displacing cooler air, this is a warm front.

There are also **troughs and ridges** that can be identified on the weather map. An area of low-pressure is called a trough. The pressure along the line on a map is lower than the pressure on either side. The isobars show a cyclonic curvature at the trough end, very similar to the contour lines in a creek bottom. Frequently a trough delineates the boundary between two different air flows and is a common place for the development of storm centers. Ridges are highs, with descending air and a minimum of cloudiness and precipitation. The pressure is higher along the ridge than on either side.

There are semipermanent "weather centers." These change by the seasons of the year. During the summer, the weather map is dominated by the Pacific and Bermuda Highs and the California Low. During the winter, the map shows the Great Basin and Arctic Highs, with the Pacific and Bermuda Highs shifting their positions. As these "major players" of weather move and shift, they affect all of us (Figure 2.47).

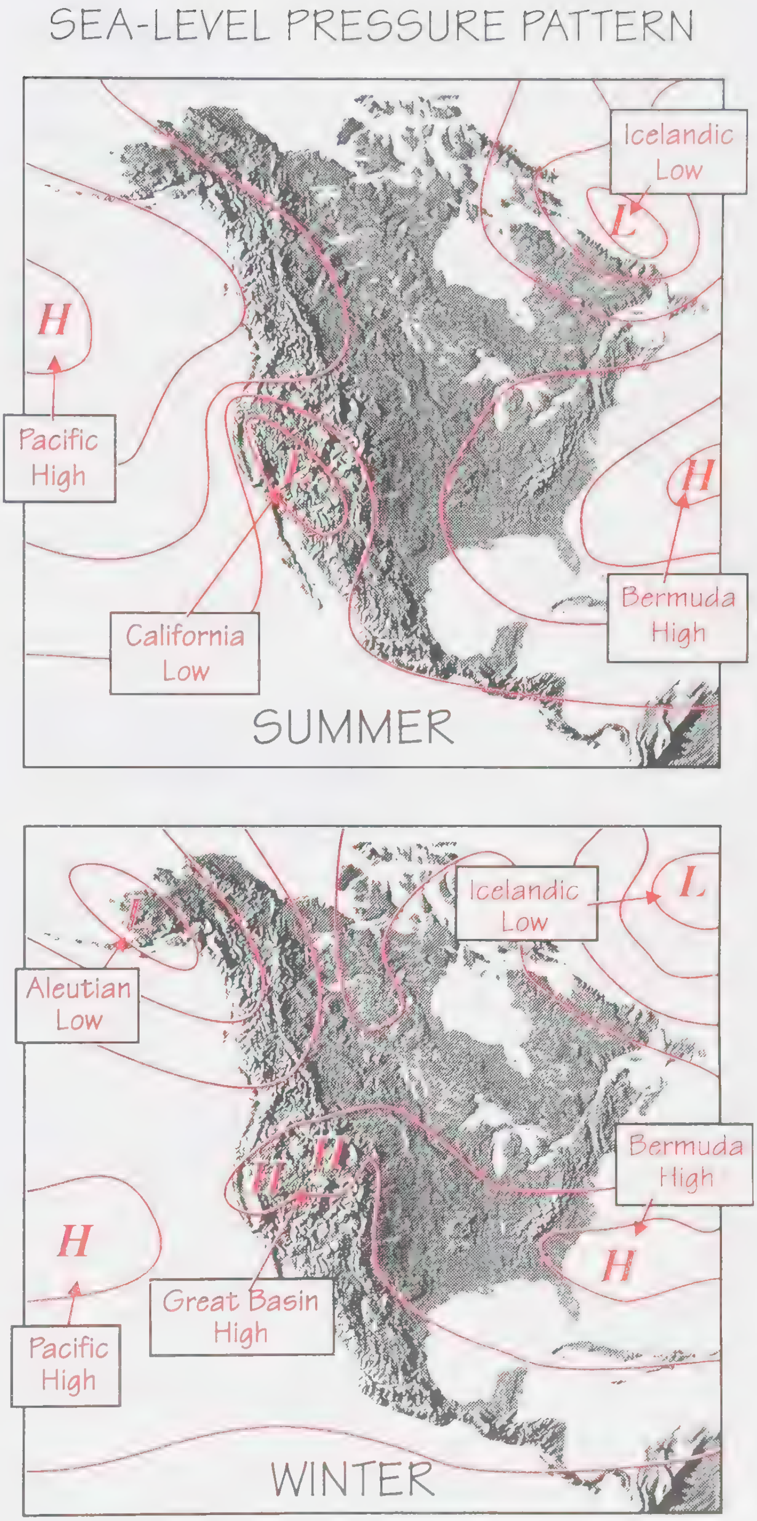

SEA-LEVEL PRESSURE PATTERN
Icelandic Low
L
H
Pacific High
L
H
California Low
Bermuda High
SUMMER
L
Icelandic Low
L
Aleutian Low
H
H
H
Bermuda High
H
Great Basin High
Pacific High
WINTER

Figure 2.47 The seasonal locations of semipermanent "weather centers."

Local Winds

Sea breezes, land breezes, slope and valley winds are all defined as local winds. These small-scale winds are caused by local temperature differences, and are strongly influenced by terrain. Local winds are just as important for fire officers to understand and consider in their plans as general winds. Local and general winds are related, but the way in which terrain influences local winds can easily obscure the relationship.

Sea breezes and land breezes are essentially the same; they just blow in opposite directions. Sea breezes are light winds that blow from the water onto the land. They usually begin in the mid-morning hours when the land is being heated by the sun and is warmer than the water. As the air over the land also heats up, it rises and draws cooler air from the sea onshore. The sea breeze pushes inland, and becomes strongest in the late afternoon during the period of maximum heating. Sea breezes usually produce winds between 10 to 20 miles per hour. However, near the coast they can be as strong as 20 to 30 miles per hour. Sea breezes are cool, with higher relative humidities. Fog or low clouds may be associated with sea breezes along the coast. Sea breezes can lower the level of fire behavior.

As the sun warms the land, air moves onshore.

The opposite occurs at night when the land is cooler than the nearby water. The wind shifts direction and moves from the land out over the sea. These land breezes usually start 2 to 3 hours after sunset, and usually end shortly after sunrise. They are lighter in speed, with a usual range of 3 to 10 miles per hour (Figure 2.48).

Slope winds are another local wind phenomena. They are diurnal (or daily) winds that are produced as the surface of the earth heats or cools. They flow upslope during the day and downslope during the night. This flow of air will continue as long as the air temperature continues to change. Downslope winds are usually gentle (2 to 5 miles per hour), smooth and very shallow (less than 20 feet deep). The principle force behind downslope winds is gravity. Upslope winds are a little stronger, usually between 3 to 8 miles per hour. Relatively calm periods exist

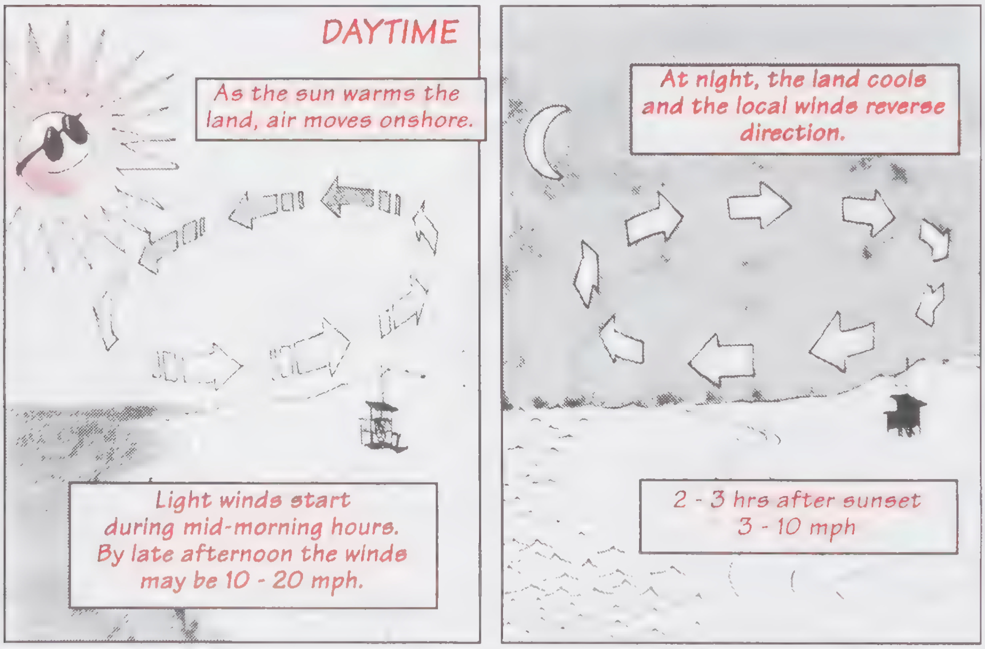

DAYTIME
As the sun warms the land, air moves onshore.
Light winds start during mid-morning hours. By late afternoon the winds may be 10 - 20 mph.
At night, the land cools and the local winds reverse direction.
2 - 3 hrs after sunset
3 - 10 mph

Figure 2.48 Sea and land breezes are created when the temperature of the water and nearby land differ.

Slope winds during the day are upslope and during the night, downslope.

during the evening and morning hours when slope winds are changing direction. Slope winds are mainly influenced by aspect, time of year, steepness of slope and current weather conditions.

Like slope winds, **valley winds** are also created by solar heating. The sun warms higher elevations first. As the warmer air at these elevations begins to rise, it draws in cooler air from below to fill the void. These upvalley winds start in the late morning or early afternoon, depending on the size of the valley; winds in large valleys tend to start earlier. Upvalley winds are stronger than upslope winds, ranging from 10 to 15 miles per hour (Figure 2.49).

Like slope winds, valley winds are created by solar heating.

Valley winds are usually stronger than slope winds.

The winds change direction at night. The earth is still radiating heat back into the atmosphere at lower elevations hours after the higher elevations have begun to cool. Warmer air at the lower elevations continues to rise, drawing cooler air from above. These downvalley winds range from 5 to 10 miles per hour.

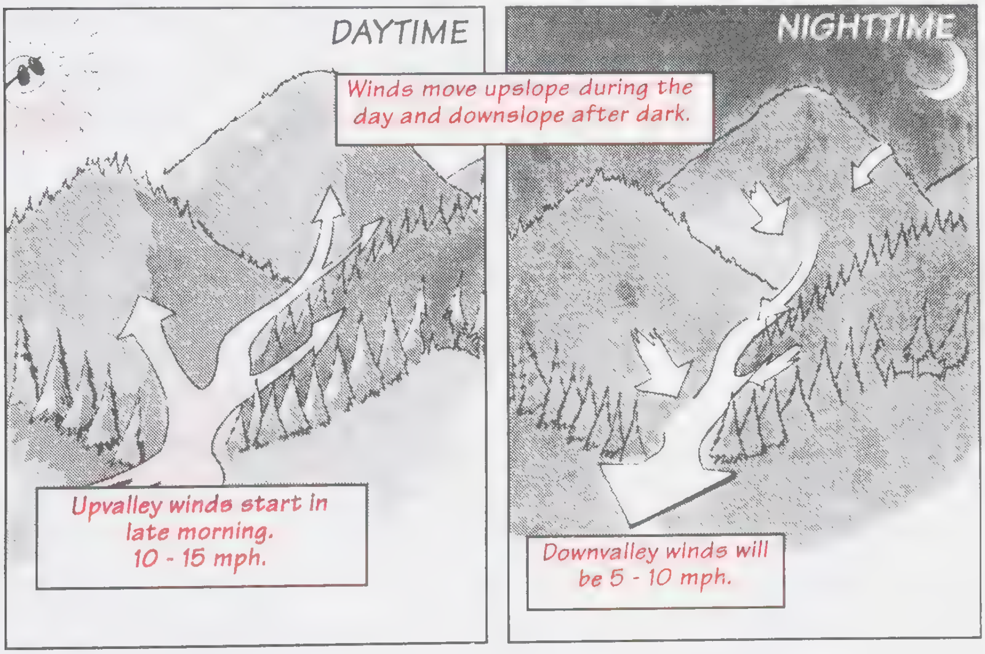

DAYTIME
NIGHTTIME
Winds move upslope during the day and downslope after dark.
Upvalley winds start in late morning. 10 - 15 mph.
Downvalley winds will be 5 - 10 mph.

Figure 2.49 Valley heating moves air up valleys and canyons during the day and down valleys and canyons at night.

The main difference between upslope winds and upvalley winds is that the upvalley winds do not start until most of the air in the valley is warmed. Slope and valley winds do not happen on

Upvalley winds do not start until most of the air in the valley is warmed.

Aspect controls when slope and valley winds will blow.

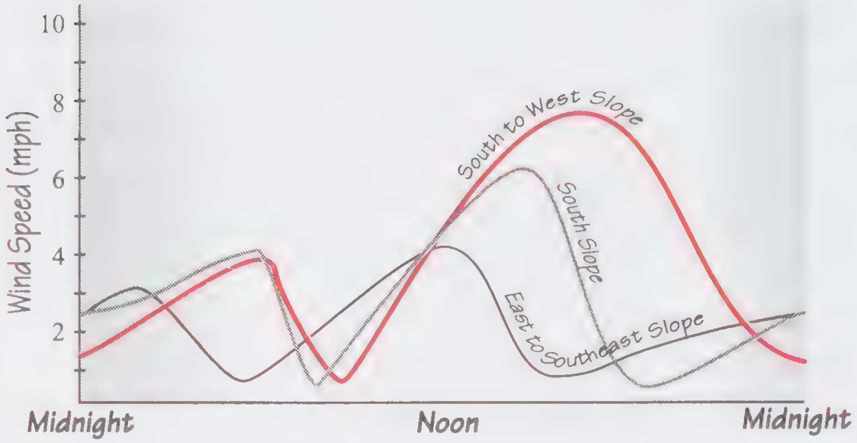

RELATIONSHIP BETWEEN TIME OF DAY AND STRENGTH OF SLOPE AND VALLEY WINDS

Figure 2.50 Aspect has an effect on the timing and strength of slope and valley winds.

all slopes and valleys at the same time and with the same speed. Aspect is the primary factor which drives these differences. Solar heating will generate breezes on east facing slopes long before south or west facing slopes (Figure 2.50).

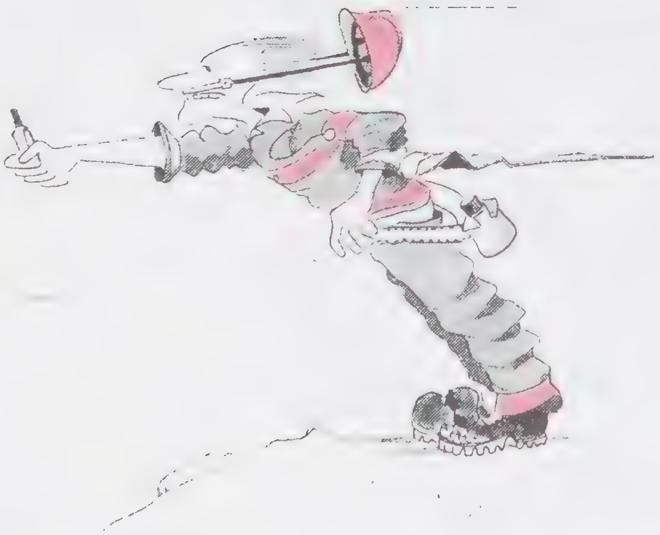


Figure 2.51 Monitoring the wind is critical. Do you think this fire officer needs an accurate wind reading, or does he have another clue?

Problem Winds

There are four wind conditions that are especially dangerous to firefighters: cold front winds; foehn or gravity winds; winds associated with thunderstorms; and whirlwinds, also referred to as "dust devils" or "firewhirls." Each of these winds can cause dramatic changes in fire behavior, endangering both life and property (Figure 2.51).

Cold Front Winds

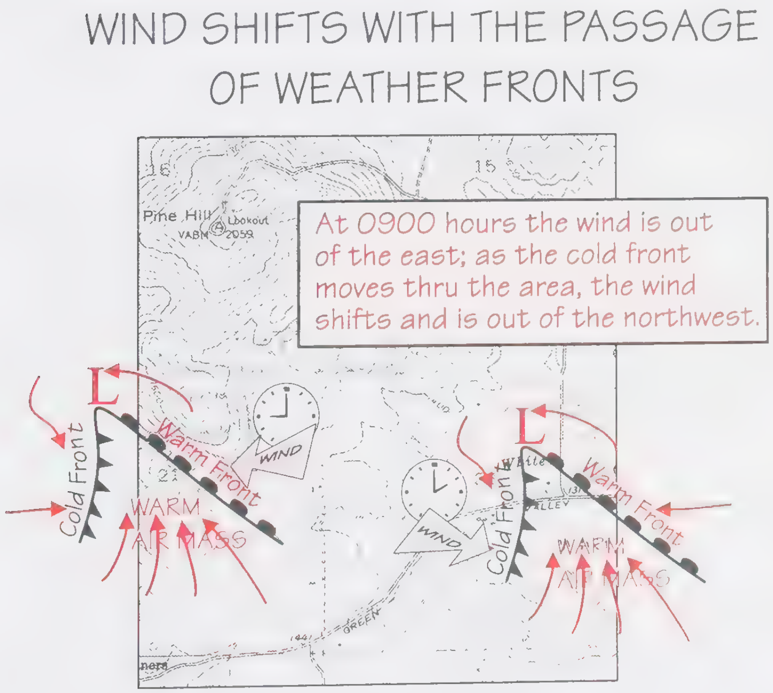
Weather fronts are boundaries between two adjacent air masses. Weather fronts are centered on low-pressure areas. A cold front is the boundary between two dissimilar air masses when the encroaching air mass is cooler. Wind changes can be dramatic as a cold front passes and may adversely affect fire behavior, especially if the cold air mass is dry. These fronts normally move at about 20 to 30 miles per hour as they are pushed by upper-level westerly winds. Figure 2.52 shows how the wind directions differ depending on the orientation with the front and low.

Cold fronts must be monitored closely. The passage of a cold front can create serious danger.

Notice how the winds change direction and speed as the front moves across the area. In advance of a warm front, winds are out of the northeast or east. Winds in advance of a cold front shift gradually from southeast to south, and then to southwest. As the cold front passes, winds shift rapidly to the west, then northwest. This change could have a dramatic impact on any fire in the area.

Windspeeds increase in strength as a cold front approaches, and usually become quite strong and gusty when the front passes through an area. When the barometric pressure associated with

Winds shift direction and speed when a cold front passes by.


WIND SHIFTS WITH THE PASSAGE OF WEATHER FRONTS

At 0900 hours the wind is out of the east; as the cold front moves thru the area, the wind shifts and is out of the northwest.

Figure 2.52 Winds will change direction and speed as a front moves through an area. The frontal system moves together as it is pushed by strong upper-level winds.

the low- pressure area is very low, there is a greater possibility that strong upper-level winds will "mix" down to the surface. Typically, cold front windspeeds range from 10 to 30 miles per hour, but can be much higher if associated with a strong front.

Summertime cold fronts are most often dry.

Thunderstorms and precipitation may be associated with cold fronts. Summertime storms are normally dry, and usually will not bring enough rain to provide much relief from the fire season. But, they do bring winds that could have a dramatic impact on your safety. Take seriously any prediction of approaching cold fronts in your area. Keep your eye on the sky and track weather changes.

Foehn Winds

Foehn winds are winds with interesting names and well deserved "bad" reputations.

Foehn winds are general winds associated with mountain ranges. When strong general winds pass over a mountain range, they descend the leeward side of the range, heating and drying the air as a result of compression. These winds are normally stronger at night because they combine with the normal local down-canyon winds. The speed of these winds generally ranges from 40 to 60 miles per hour, but there have been cases when foehn winds have reached 100 miles per hour. Foehn winds are historic in nature, and have been given local names (e.g., Santana, Chinook, and Mono).

The most famous of all the foehn winds are the Santana Winds of Southern California.

Santana Winds occur in the southern portions of California. They are created when there is a strong high-pressure area in the Great Basin and a low-pressure area located above the Pacific Ocean along the Southern California coast. This condition would normally produce a strong general wind. However, this wind is heated and dried as it crosses the coastal mountain range and drives toward the ocean. The results are predictable and potentially disastrous. As the Santana Winds approach the ocean, they begin to subside. At this point, the Santana and marine onshore winds begin to "battle" for supremacy. During this battle for supremacy, the winds can abruptly change 180° in direction. Such a change can "ruin your whole day" if you're trying to fight a fire.

Chinook Winds occur in the Rocky Mountains. They blow out of the northwest and up the western slopes, producing clouds over the mountain peaks. As they race down the eastern slope, they become hot, dry and gusting (Figure 2.53).

North Winds in northern California are produced in the same way as the other foehn winds, and can sometimes be an indication (or warning) of developing Santana winds.

Eastern Winds are foehn winds of Washington and Oregon. They are produced as general winds pass over the Cascade Mountain Range.

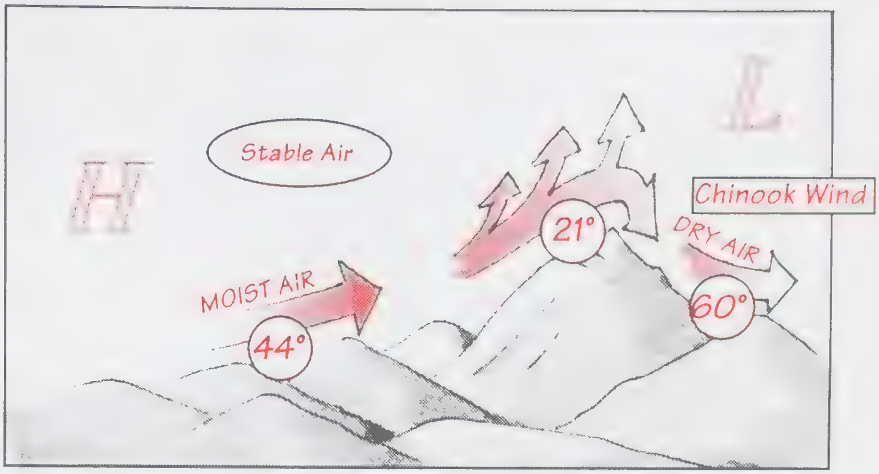


Figure 2.53 Chinook winds run down the east slopes of the Rocky Mountains.

Thunderstorm Downdrafts

If you are fighting fire in an area where thunderstorms are either present or predicted, be careful! If you are between a fire and an approaching thunderstorm, you are in a very dangerous environment. You should be concerned long before you can see the lightning or hear the thunder. This cannot be stressed enough!

You should be concerned long before you see or hear a thunderstorm.

Like wildland fires, all thunderstorms start small and usually innocently. Thunderstorms (cumulonimbus clouds) develop when there is adequate atmospheric moisture, instability, and a force that will cause the air to rise. The most common lifting force is convection brought on by solar heating. Thunderstorms can rise to 30,000 to 40,000 feet in the West and 40,000 to 60,000 feet in the East. When they develop to this size, they can store tremendous energy. This energy is the source for lightning, rain, hail, and strong, gusty winds.

A thunderstorm's effect may extend 25 to 30 miles from the actual storm.

Downdrafts in a thunderstorm develop as air moves down through the center of the cloud. As this air descends in a thunderstorm, it is cooled by evaporation. Cooling makes the air heavier, accelerating its downward movement. This denser air is also pulled by the gravitational force of the earth. Picture the thunderstorm downdraft as a pitcher of cold air being poured onto a table; as the air strikes the table (or terrain) it spreads in all directions (Figure 2.54). These cool, gusty winds (sometimes called a gust front or microburst) can be felt up to 10 miles from the storm center. This effect can reach much farther in the mountains because of the funneling effect created by ridges and canyons. The winds created by the downdrafts contain more moisture than surrounding air, and can range from 25 to 35 miles per hour, with gusts to over 60 miles per hour. The wind speed is the dominating force that you must be concerned with.

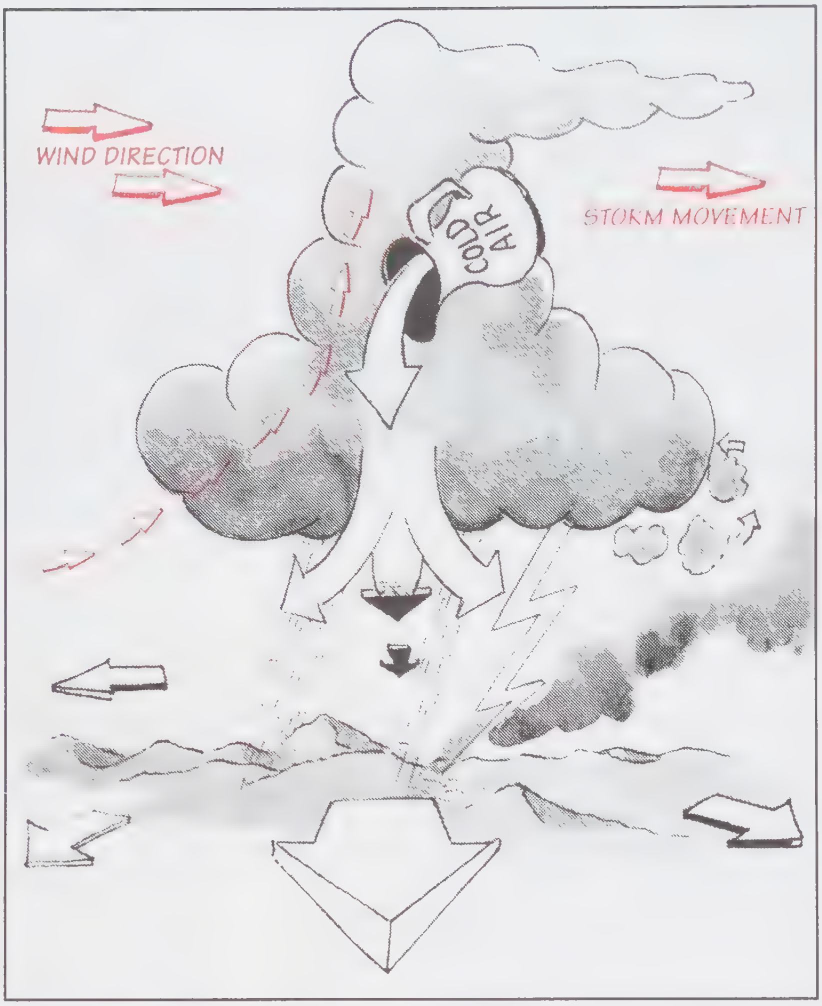


Figure 2.54 When a thunderstorm breaks down, strong downdrafts develop. It is like pouring cold air from a pitcher.

Thunderstorms have a "life expectancy" of less than 12 hours. Thunderstorms created by convection generally don't form until afternoon, when there is sufficient solar heating to lift the moisture-laden air to great heights. They begin to break down before midnight. There are several indicators that a thunderstorm is mature and that downdrafts may become a serious concern:

- The base of the cloud begins to "roll" on the downwind side.
- Virga begins to "hang" under a darkened, ragged cloud base (Figure 2.55).
- A dust cloud can be seen on the ground as the first gusts of wind reach the surface.

A thunderstorm is mature and downdrafts may become a problem when the base of the cloud begins to "roll", virga is present and/or a dust cloud begins to develop.

Thunderstorms may either remain stationary or move with the prevailing winds. Indrafts can continue moving into the base of the cloud even as downdrafts are pouring from the center of the storm. The downdraft winds will normally be stronger on the downwind side of the storm as they can combine with the force of the prevailing wind.

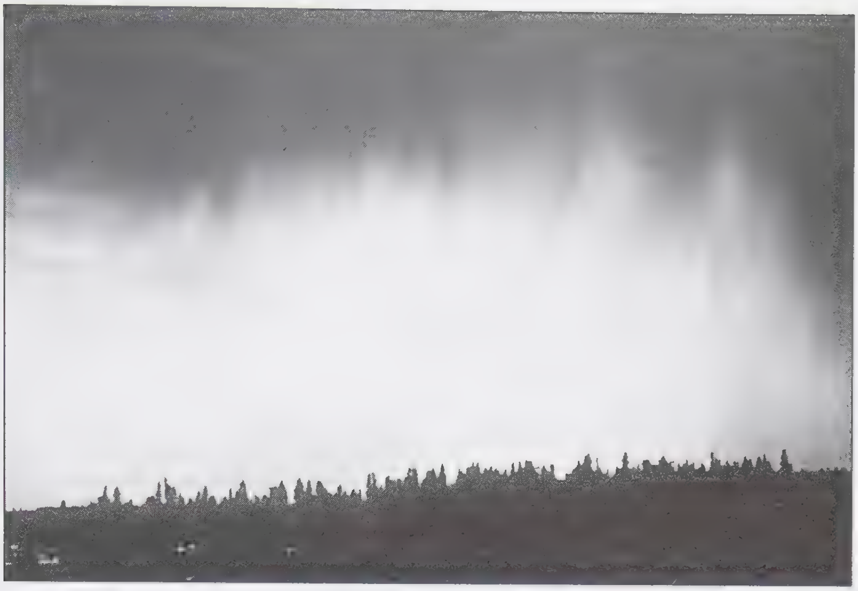


Figure 2.55 Virga is an indicator that a thunderstorm has "matured."

Virga under a thunderstorm is an indication the storm is mature...downdraft winds may be in your future.

Whirlwinds, Dust Devils and Firewhirls

Whirlwinds, dust devils and firewhirls are miniature cyclones that are caused when strong convection currents and updrafts develop. Dust devils are whirlwinds that have "kicked up" dust; firewhirls are whirlwinds that have picked up burning material, or are present in or near the flame front of a fire. They can occur under the following conditions:

- Mostly clear skies - a sign that the air might be unstable.
- Light surface winds - strong surface winds hamper the development of strong convective columns.
- Strong solar heating.
- On the backside of a ridge, or on the lee slope from the prevailing wind.

Whirlwinds, dust devils and firewhirls can range in size from a few feet across and hundreds of feet in height, to over 100 feet in diameter and thousands of feet high. Whirlwinds and dust devils are common in areas that have just burned over; the black ash bed is a better absorber of solar radiation, thus encouraging local heating (Figure 2.56).

Whirlwinds and dust devils are common in areas that have just burned.

Firewhirls contain very hot gases, flames and burning material. They can lift this material to considerable heights and deposit

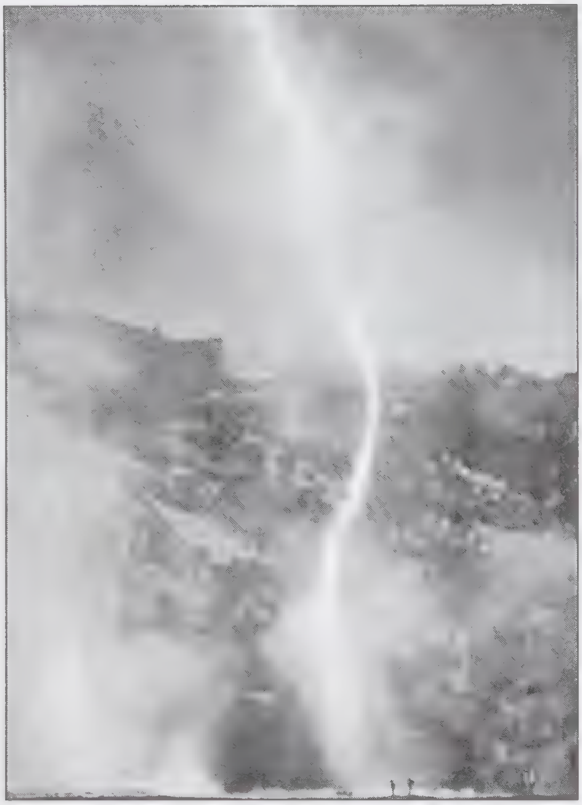


Figure 2.56 Dust devils are a definite indication that the atmosphere is very unstable.

it in some very "inconvenient" locations, like across your fireline (Figure 2.57).

The Effect of Topography on Wind

The topography of an area has definite effects on wind speed and direction. These effects can be categorized as mechanical, turbulent, or frictional. There are three mechanical or diverting effects that topography has on wind (directional channeling, venturi, and wave action):

Directional channeling of a general wind occurs when the wind direction changes and flows in the direction of a canyon.

Venturi effect occurs as a general wind flows through a pass, saddle or gorge. The wind speed increases as it funnels through the opening.

Wave action is caused when a general wind moves across a mountain range at a 90° angle. A wind wave is formed on the lee side of the range, causing very turbulent air (Figure 2.58). This wind wave can hamper air operations and can be the source of strong up-and-downdrafts. The real impact on firefighting may occur when the wind wave influences the normal daily heating in the basin on the lee side of the mountain range. If the convected air from the basin mixes with the turbulence of the wind wave, the strong upper-level general winds may be drawn to the surface and have a spectacular impact on fire behavior. One of the best indicators that a wave action is occurring is an "indicator cloud" called **altocumulus lenticular** (See Figure 2.37, page 71). This unique cloud remains stationary as the air moves through it. It is found over the ridgetop, or on the lee side of the mountain range.

Wind wave action may cause very turbulent air on the lee side of a ridge or mountain range, and create spectacular effects on fire behavior.

There are three types of turbulent effects (lee side turbulence or eddying, canyon or valley winds, and thermal):

Lee side turbulence or **eddying** occurs on the lee side of an obstruction like a range of mountains. These winds (eddies) can move either vertically or horizontally. They are caused by a combination of wind speed, orientation of the wind to the obstruction, and stability of the atmosphere.

Strong winds in canyons can also cause eddies, which occur to the lee of spur ridges. Eddies are most pronounced during the late afternoon when canyon or valley winds are at their peak.

Thermal turbulence is caused by differences in surface heating. This type of turbulence causes low-level winds to become gusty and erratic.

Finally, there is **frictional drag** which occurs when wind is slowed by friction as it nears and moves over the surface. The "roughness" of the earth's surface causes this drag. Such things as vegetation, terrain features and man-made structures slow winds. The rougher the terrain or vegetation, the more the wind speed is reduced. Windspeed over open, level ground decreases rapidly as you get close to the surface. On the ground there is virtually no wind.

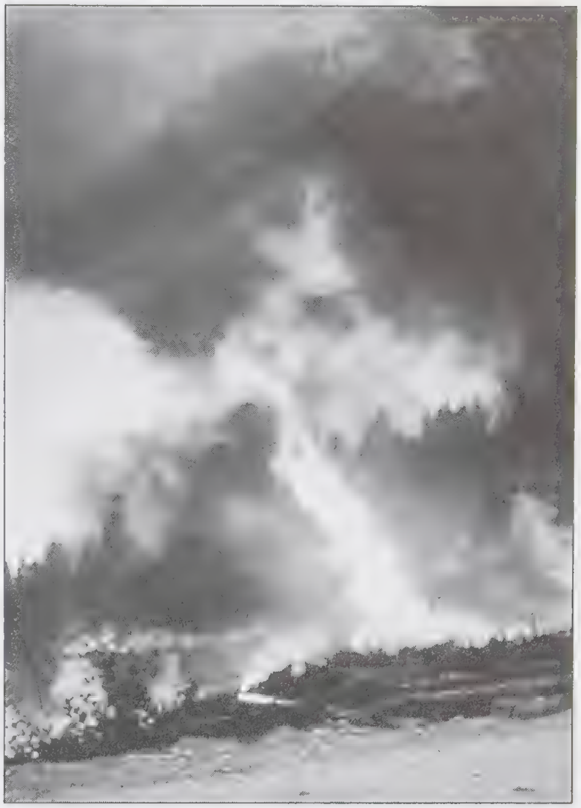


Figure 2.57 Firewhirls can carry fire across control lines or cause spotting.

Wind Speed and Direction

Earlier in the chapter, we discussed four different types of winds that you should be familiar with. Let's review them briefly before we tie in the concepts of speed and direction. General winds are those winds that are blowing over large areas. These are the winds that are reported in daily weather forecasts. Local winds are the result of local factors such as temperature differences and terrain. Surface winds are local winds impacted by general winds. Weather forecasters have standardized the definition of

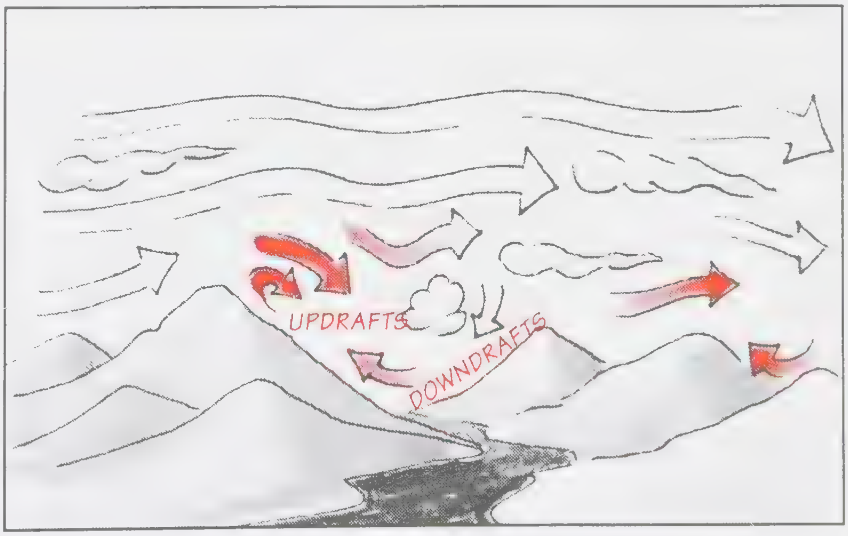


Figure 2.58 The wave action created when a strong upper level wind passes over a mountain range can cause strong updrafts and downdrafts.

surface winds as meaning winds which are 20 feet above the average vegetation cover. Midflame winds are those which occur at the midpoint of the flame height. They have a direct impact on the movement of the fire front, and thus on the speed and direction of fire spread.

Local winds are the result of local factors, such as temperature differences and terrain.

General winds impact local winds in several ways. General winds may combine with locally developed upslope or valley winds. The combined wind speed will be a product of the general wind speed (minus frictional drag) plus the local wind speed. The reverse would occur if the winds were coming from opposite directions. If an inversion layer is present, the general winds may only impact local winds above the inversion layer (Figure 2.59).

How Winds Affect Fire

Surface winds are local winds influenced by the general wind.

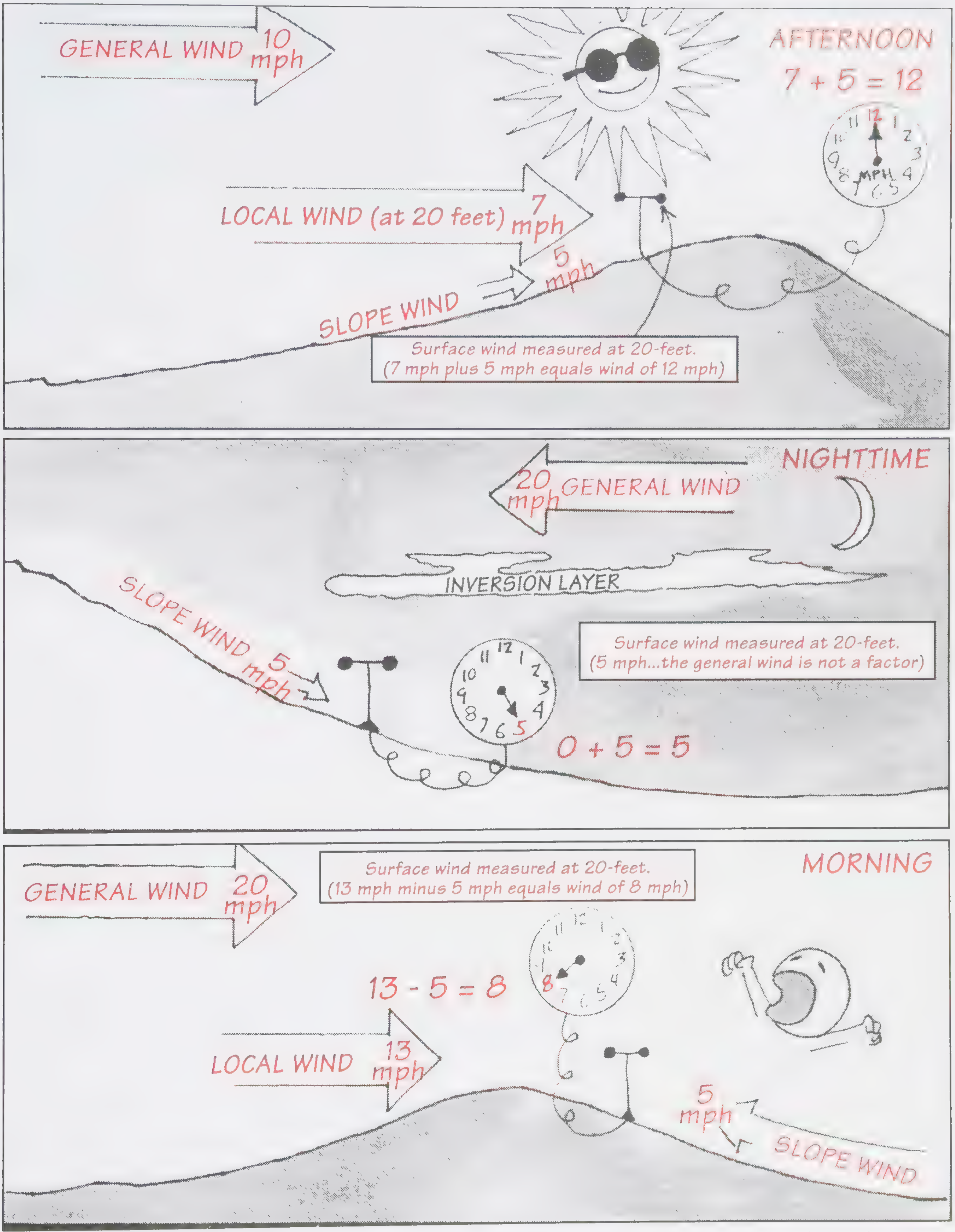
Specific winds affect a wildland fire in different ways. The winds that most influence the direction in which the **flame front** moves, are the midflame winds (Figure 2.60). Midflame winds are used in calculating the rate of fire spread. Local or general winds, however, may have a greater influence on the overall direction a fire moves, if spotting is a factor. These are the winds that are going to carry burning embers to other locations.

The midflame wind has the most influence on which way a fire will burn.

Midflame winds range from 10 percent of the 20-foot winds in closed timber, to 60 percent of the 20-foots wind in certain brush-type fuels. Midflame winds can be calculated using a wind reduction table (Figure 2.61), or they can be measured directly. An eye-level wind measurement taken using a belt weather kit gives you a good approximation of the midflame wind over a wide range of fuel types.

Wind profiles provided by the weather service can give you an idea of what is happening aloft.

Wind speed and direction can have a dramatic effect on fire behavior. That is why you need to track them. Although wind is also one of the hardest weather elements to predict, you can obtain speed and direction of winds aloft from the weather service. Weather balloons are released and tracked twice a day. As these balloons rise through the atmosphere, they provide very valuable information that can be used to produce a wind profile (Figure 2.62). Note that the wind can be very dynamic; it can blow at different speeds and from different directions at different heights.



Surface wind measured at 20-feet.
(7 mph plus 5 mph equals wind of 12 mph)

Surface wind measured at 20-feet.
(5 mph...the general wind is not a factor)

Surface wind measured at 20-feet.
(13 mph minus 5 mph equals wind of 8 mph)

GENERAL WIND 10 mph
AFTERNOON
7 + 5 = 12
MPH
LOCAL WIND (at 20 feet) 7 mph
5 mph
SLOPE WIND
NIGHTTIME
20 mph GENERAL WIND
INVERSION LAYER
SLOPE WIND 5 mph
0 + 5 = 5
GENERAL WIND 20 mph
MORNING
13 - 5 = 8
LOCAL WIND 13 mph
5 mph
SLOPE WIND

Figure 2.59 If the general and local winds are moving in the same direction, the wind speeds are added; if the general and local winds are opposing, the wind speeds are subtracted.

Flame length is an indicator of burning conditions.

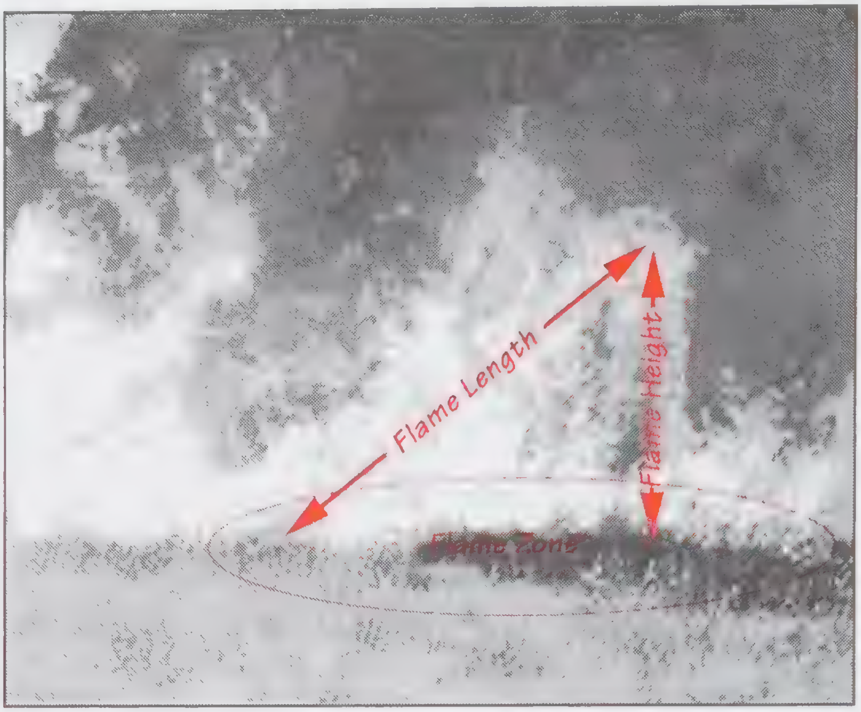


Figure 2.60 Midflame height is one-half the flame height.

Even though you may have a current fire weather forecast, you should develop the habit of taking and recording your own weather information. Only in this way can you really get a sense of how the weather is impacting, or can impact your fire suppression activities. It is also the only way you will be able to detect a potential change in the weather. You cannot rely only on "how the weather feels." At a minimum you must track the temperature, relative humidity, wind speed and direction to really detect change.

There are two drought indexes that you should be familiar with; the Palmer Drought Severity Index and the Keetch-Bryam Drought Index.

Drought Indexes

There are two commonly used drought indexes, the Palmer Drought Severity Index and the Keetch-Bryam Drought Index both of which can "predict" the potential for severe fire conditions.

The **Palmer Drought Severity Index** (commonly referred to as the PDI) was developed years ago as a tool to predict soil moisture deficiencies, and assess crop potential for the farming community. It is only recently that firefighters have begun to use PDI to develop a general sense of the status of the fire season.

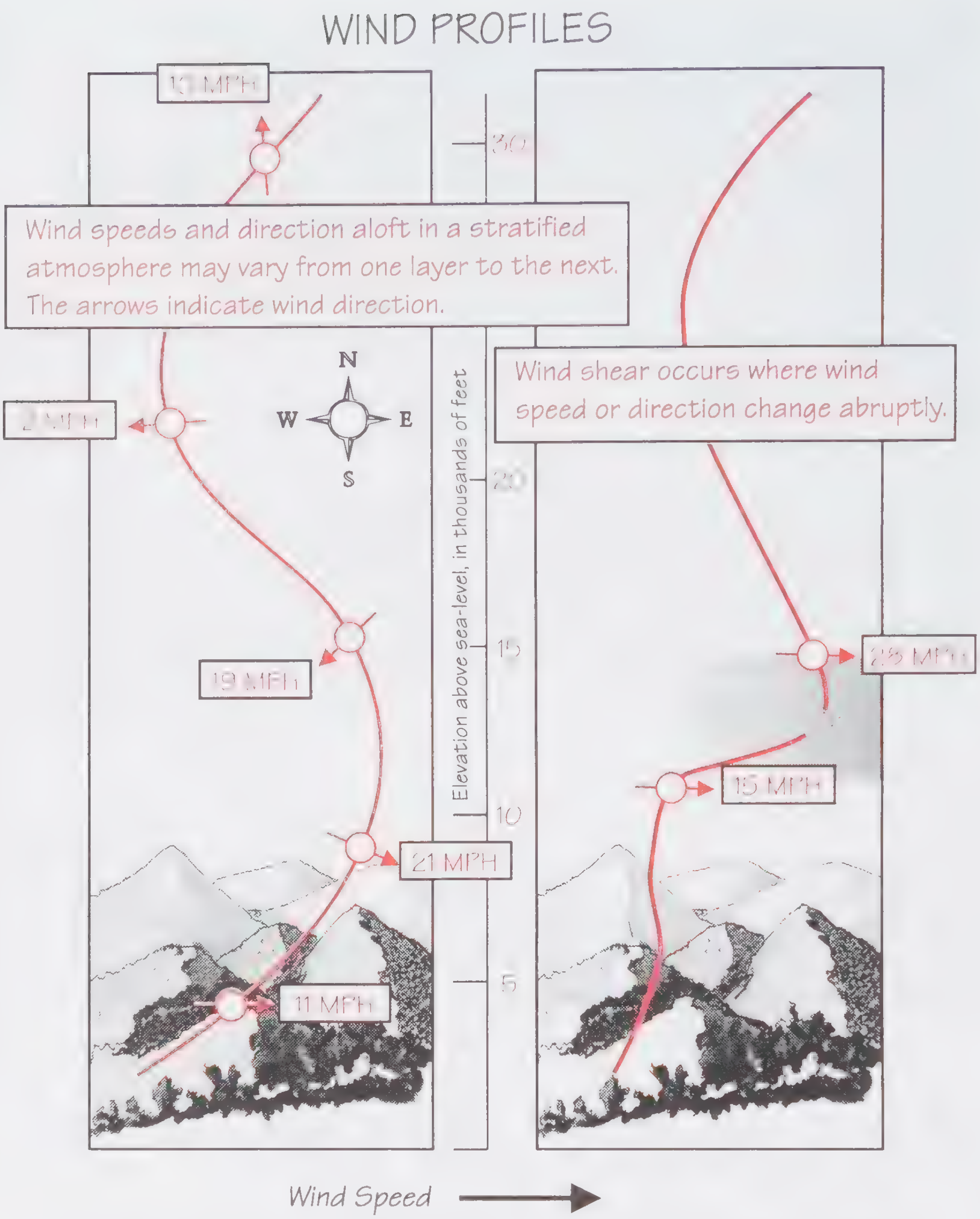
MIDFLAME WIND ADJUSTMENTS

Fuel exposure	**Fuel type**	**Adjustment factor**
EXPOSED FUELS - Fuel exposed directly to the wind. No or sparse overstory. Fuel beneath timber that has lost its foliage overstory; fuel beneath timber near clearings or clearcut; fuel on high ridges where trees offer little shelter from the wind.	Brush 6 foot tall or taller (4) or heavy slash (13)	0.6
	All other fuel types	0.4
PARTIALLY SHELTERED FUELS - Fuel beneath patchy timber where it is not well sheltered; fuel beneath standing timber at midslope or higher, on a mountain with wind blowing directly at the slope.	All fuel types	0.3
FULLY SHELTERED FUELS - Fuel sheltered beneath standing timber on flat or gentle slope, or near base of mountain with steep slopes.	All fuel types	0.2 Open Stands 0.1 Dense Stands

Figure 2.61 Midflame wind adjustments chart. Use this chart when you want to convert 20-foot wind information to midflame wind speeds.

The United States is divided into 344 climate divisions (Figure 2.63). Every two weeks the National Weather Service calculates and publishes the PDI for each of these divisions. Temperature, rainfall and other weather factors are used in the calculation of the PDI. It uses a numerical rating from -6 to +8. Zero represents normal conditions for the weather climatic division. A PDI of -3 indicates severe drought conditions; a -4 indicates extreme drought. This index is calculated by the National Weather Service every two weeks.

The Palmer Drought Severity Index is calculated every two weeks.


WIND PROFILES
13 MPH
30
2 MPH
N
W
E
S
Elevation above sea-level, in thousands of feet
20
15
19 MPH
28 MPH
15 MPH
10
21 MPH
5
11 MPH
Wind Speed

Wind speeds and direction aloft in a stratified atmosphere may vary from one layer to the next. The arrows indicate wind direction.

Wind shear occurs where wind speed or direction change abruptly.

Figure 2.62 Wind profile information can be obtained from weather forecasters.

The Keetch-Bryam Drought Index is calculated daily.

If you are in an area that is experiencing drought conditions (PDI of - 3 or lower) you should consider the fuels to be critically dry. And, if you have a fire burning towards a southern slope in the afternoon, you should make certain to be out of its way when it "hits the ridge." Figure 2.64 shows the average PDI figures for the State of California for the hundred year period starting in 1895. Note that there have been several periods of severe drought, most of which were also bad fire years. There have been other bad fire years, but most of those were the result of wind-driven conflagrations.

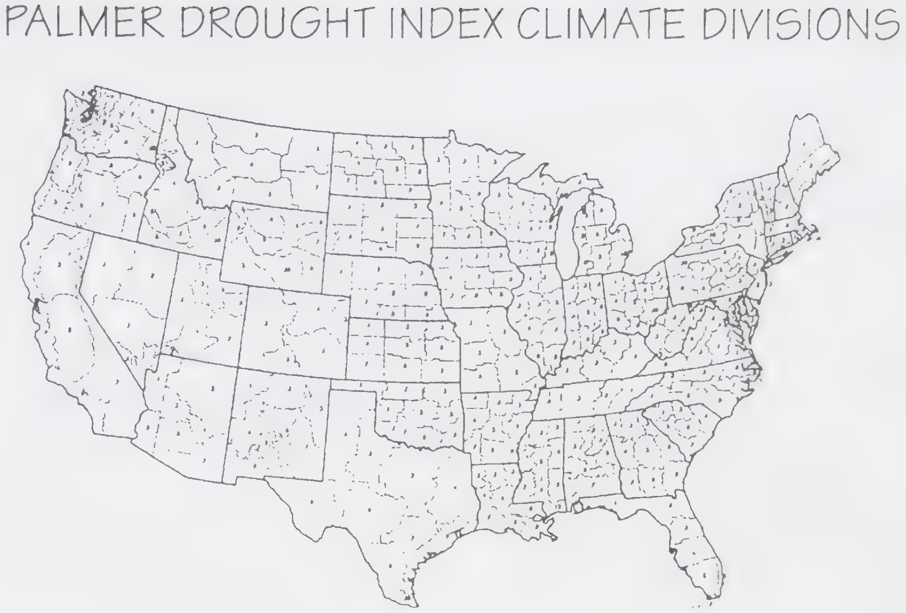


Figure 2.63 The United States is divided into 344 climate divisions.

The **Keetch-Bryam Drought Index** is a soil/duff drought index that is calculated based on the maximum daily temperature, daily precipitation, and annual precipitation. This index is calculated daily. The scale ranges from 0 (no drought) to 800 (extreme drought).

0 to 200 Soil moisture and large class fuel moisture are high and do not contribute much to fire intensity. This is a typical condition of the spring dormant season, following winter precipitation.

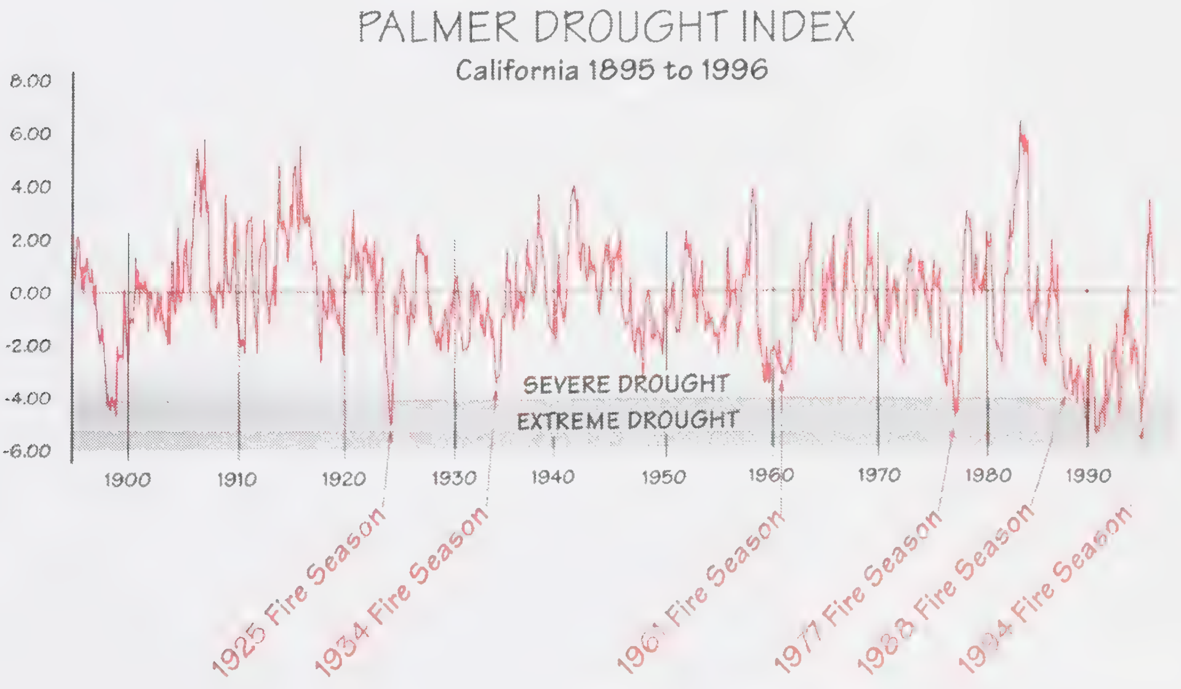


Figure 2.64 The Palmer Drought Index calculations for the State of California dating back to 1895. As expected, some of the most severe fire seasons occurred during drought years.

200 to 400 Typical of late spring, early growing season. Lower litter and duff layers are drying and beginning to contribute to fire intensity.

400 to 600 Typical of late summer, early fall. Lower litter and duff layers actively contribute to fire intensity and burn actively.

600 to 800 Often associated with more severe drought with increased wildland fire occurrence. Intense, deep burning fires with significant downwind spotting can be expected. Live fuels can also be expected to burn actively at these levels.

National Fire Danger Rating System

The National Fire Danger Rating System (NFDRS) has its origins in the 1920s, when USDA, Forest Service fire managers began development of regional fire danger "meters" or "scales." These systems were intended to measure relative fire conditions, and attempt to apply a numerical rating to each day during the fire season. In 1958 the development of a national system was begun. In 1972 the first comprehensive system became operational. The 1972 version of NFDRS was revised in 1978.

Forestry Canada has developed its own version of a fire danger rating system. It is designed around their fuels, weather and general fire problem. There are those in Alaska who feel the Canadian system more accurately reflects Alaska's fire problem. This position causes concern to those who feel there is a need for a single system.

Most wildland firefighters don't understand or appreciate NFDRS. Their only contact with it may have been the requirement to take weather readings twice a day and report them to headquarters. Even though much of the information presented by NFDRS is of little use to the individual firefighter or fire officer, there are certain elements of it that you should understand and use.

The National Fire Danger Rating System is a fire potential prediction system.

NFDRS is not a fire prediction system. It is a series of individual indexes, developed to provide "relative" information about current and predicted fire conditions. Rather than predicting anticipated fire behavior in a specific location, it reflects potential "worst case" fire danger for wide areas (100,000 or more acres).

The specific intent of NFDRS is to provide fire managers with information regarding relatively short term fire danger conditions.

NFDRS is a useful tool for determining how to best plan for and respond to a wildland fire:

Pre-fire deployment of resources - Knowing the risk potential makes it possible to better deploy both personnel and equipment throughout an area. On those days when the fire danger is very high, some agencies increase staffing during daylight hours, and/or have patrols roving through wildland or urban-interface areas in order to provide faster response if a fire does occur.

NFDRS provides information that can be used to pre-position personnel and equipment.

Suppression - Once again, when the fire danger is very high, fire agencies often dispatch additional units on the initial response to get more resources on scene faster.

Detection - Additional detection systems (fixed lookouts, aerial patrols, etc.) may be activated, if conditions warrant.

Prevention - Some agencies need to regulate natural and prescribed burning activities. Sometimes it is necessary to abstain from prescribed burning due to the high fire danger. Other times the prescribed burning is necessary to reduce the fire risk. NFDRS is very useful for determining when to burn and when not to. It's also useful when describing fire conditions to the media and the general public, particularly when they question your decisions or want to know why certain activities are restricted in an area.

Figure 2.65 shows the structure of the National Fire Danger Rating System. It was included, not for you to memorize, but to give you an idea of how various factors are related. It incorporates several elements:

- Weather and fuel information (including lightning activity, temperature, relative humidity, cloudiness, wind speed, and fuel temperature and moisture).
- Components or indexes that predict fire behavior (Energy Release component, Spread Component, Ignition Component, and Burning Index).
- Potential for a fire to start (either from lightning or human activities).
- Overall fire load.

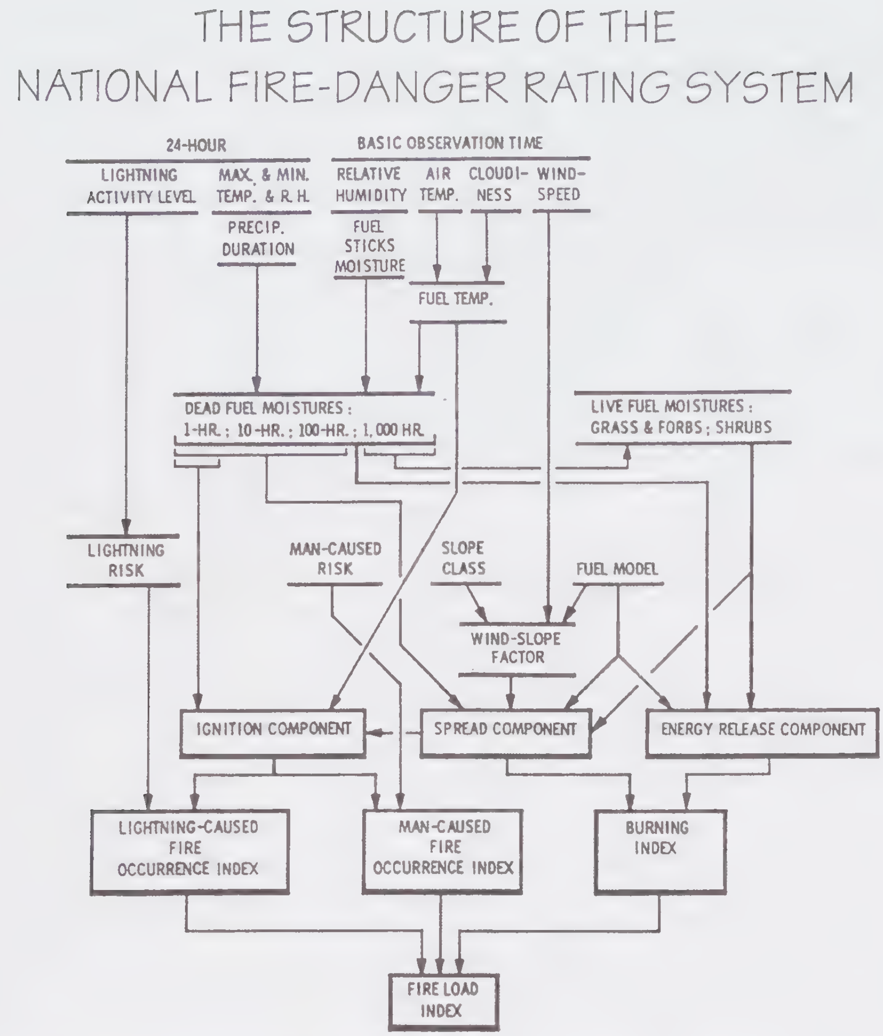

THE STRUCTURE OF THE
NATIONAL FIRE-DANGER RATING SYSTEM
24-HOUR
BASIC OBSERVATION TIME
LIGHTNING ACTIVITY LEVEL
MAX. & MIN. TEMP. & R.H.
RELATIVE HUMIDITY
AIR TEMP.
CLOUDINESS
WIND-SPEED
PRECIP. DURATION
FUEL STICKS MOISTURE
FUEL TEMP.
DEAD FUEL MOISTURES: 1-HR.; 10-HR.; 100-HR.; 1,000 HR.
LIVE FUEL MOISTURES: GRASS & FORBS; SHRUBS
LIGHTNING RISK
MAN-CAUSED RISK
SLOPE CLASS
FUEL MODEL
WIND-SLOPE FACTOR
IGNITION COMPONENT
SPREAD COMPONENT
ENERGY RELEASE COMPONENT
LIGHTNING-CAUSED FIRE OCCURRENCE INDEX
MAN-CAUSED FIRE OCCURRENCE INDEX
BURNING INDEX
FIRE LOAD INDEX

Figure 2.65 The relationships of the various components of the National Fire Danger Rating System.

This information can give the fire officer a relative idea of how easily a fire may start, its potential for growth, and how difficult it may be to control. The components and indexes that are of most value to the fire officer are as follows:

Energy Release Component (ERC) is an estimate of the potential energy release in the flaming zone of the fire. This will have a direct bearing on your tactics; the higher the ERC, the harder a fire will be to suppress. The ERC traces the seasonal trends in fire danger, rather than short term fluctuations in fire danger.

Spread Component (SC) predicts the rate of fire spread based on predicted wind, slope and fuels. Since this component uses wind and fuel moisture in its calculations, it is much more sensitive to short-term changes in conditions (Figure 2.66).

The ignition component provides an estimate of spotting potential.

Ignition Component (IC) is an estimate of the likelihood of spot fires developing. It is the one index which is most sensitive to changing conditions. IC is derived by using air and fuel temperatures, relative humidity, and cloudiness to estimate the percent of firebrands that may start a spot fire. An IC of 45 indicates that 45 of 100 firebrands are likely to start new fires. An IC of 80 is an estimate that 80% of any firebrands will start new fires. This is one of the elements of NFDRS that you should learn to use.

SPREAD COMPONENT RATINGS

Index	Start potential	Spread potential	Control potential
Low 0 - 30	Minimal, precipitation may be present.	Slow, smoldering, very little spotting.	No special problems.
Moderate 31 - 50	Most often from accidental causes.	Slow to moderate, some spotting likely.	No special problems.
High 51 - 70	Fairly easily from most causes.	Rapid, spots easily.	May be difficult, hit hard while small.
Very High 71 - 90	Easily from most causes.	Develops fast, high rate of spread, much spotting.	Direct attack at head is unsafe.
Extreme 91 - 100	Easily from any cause.	Burns intensely, rapid spread, frequent spotting.	Only flank should be attempted. Be alert for potential blowups.

Figure 2.66 The Spread Component ratings.

Burning Index (BI) attempts to estimate how a fire will burn once started. It is a measure of the heat intensity released by the fire, and is calculated by combining the Spread Component (SC) and Energy Release Component (ERC) described above. The fire officer can use the burning index to predict flame length; the predicted flame length is one-tenth the burning index. If, for example, the burning index is 80, the predicted flame length will be 8 feet. With that kind of flame length, a direct attack on the head of the fire may not be possible (Figure 2.67).

The predicted flame length is one-tenth the burning index.

The other indexes are predictors of new fire starts, either man-caused or lightning-caused. If you combine the potential for new fire starts with the burning potential of these fires, you get the **Fire Load Index** (FLI). Remember, these estimates of fire potential are not directly related to fire behavior predictions, but rather an estimation of how difficult it will be for you to suppress a fire once it starts. These numbers will not tell you how far over the hill your fire will burn.

Status of the Weather

If you do not know the current status of the weather, both actual and forecasted, you may as well toss a coin to determine

BURNING INDEX RATINGS

Index	Length of day	Humidity and temperature	Fuel state	Resistance to control
Low 0 - 30	Long; burning period moderate.	High to moderate humidity. Temperature moderate.	Fine fuels in green stage.	Low
Moderate 31 - 50	Long; burning period moderate.	Moderate humidity. Temperature moderate.	Fine fuels in transition.	Moderate
High 51 - 70	Long; burning period prolonged.	Moderate to low humidity. Temperature high.	Fine fuels in transition.	High
Very High 71 - 90	Long; burning period prolonged.	Humidity moderate to low at night also temperature high, little cooling at night.	Fine fuels in curing state.	High
Extreme 91 - 100	Long; burning period prolonged.	Very low humidity. Temperature high, little cooling at night.	Fine fuels are cured.	Extreme

Figure 2.67 The Burning Index ratings.

your plan of attack. Accurate, current weather information is that important! This doesn't mean that you need to have a sophisticated weather station or satellite link to receive the latest data (Figure 2.68). It does means that you should make some simple local observations and record them. You also need a general idea of what is predicted for the next couple of hours.

As a fire officer, you should be realistic about what level of weather information you need. The key is that you must be able to detect changing weather conditions. As noted previously, at a minimum, you should record these weather factors every hour or so:

- Temperature
- Relative humidity
- Wind speed and direction
- Indications of changing air stability, thunderstorm buildups, approaching cold fronts, or a lifting inversion layer.

You don't have to be a meteorologist to take the weather.

One tool for tracking the weather status on the fireline is a belt weather kit. These kits are available through any fire equipment supplier. They include a psychrometer, a wind speed meter, and a slide rule to determine relative humidity.

The psychrometer is used to record the temperature of dry air, and the temperature of evaporating water. Most psychrometers require some manual operation; some are battery operated. Sample the temperature in a representative area, not in the burn. Stand in the shade, facing the wind. If you are using a sling psychrometer, swing it 40 to 50 times, recording the dry bulb temperature and wet bulb temperature once they stabilize. Sling psychrometers are drawn to hard, stationary objects (Figure 2.69).

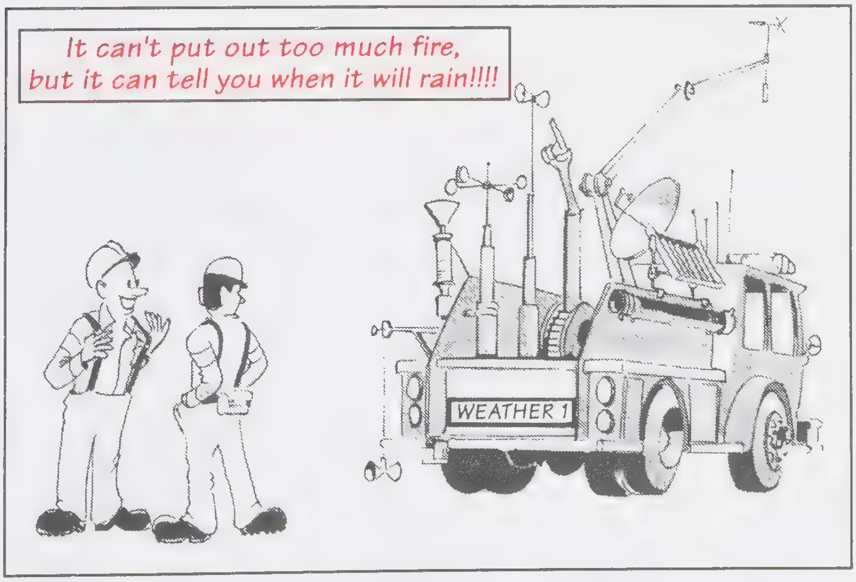

It can't put out too much fire,
but it can tell you when it will rain!!!!
WEATHER 1

Figure 2.68 This fire officer is prepared. He doesn't have any hose on his engine, but he knows what the weather is doing!

Don't underestimate the power of the psychrometer to attract solid objects.

Give yourself plenty of room when using one. When you break one, don't blame it on the hardness of the water!

To determine the wind speed (at eye level), face the wind, holding the wind speed meter at arms length in front of you. Observe the small ball as it rises in the tube. The ball will move up and down in the tube; do your best to record an average wind speed reading.

Every fire officer should have a belt weather kit.

If the weather factors noted on page 102 are recorded every hour, you will be able to spot subtle changes that may mean a change in fire behavior. You don't need a 3-day forecast unless you're planning for an extended incident. You need an idea of what to expect in the next few hours in order to safeguard your crew and make sound decisions on the fireground. The morning weather forecast may help you develop a short-term (two to four hours) weather picture. But, you need to evaluate actual conditions on the fireground, and be able to anticipate and spot indications of change.

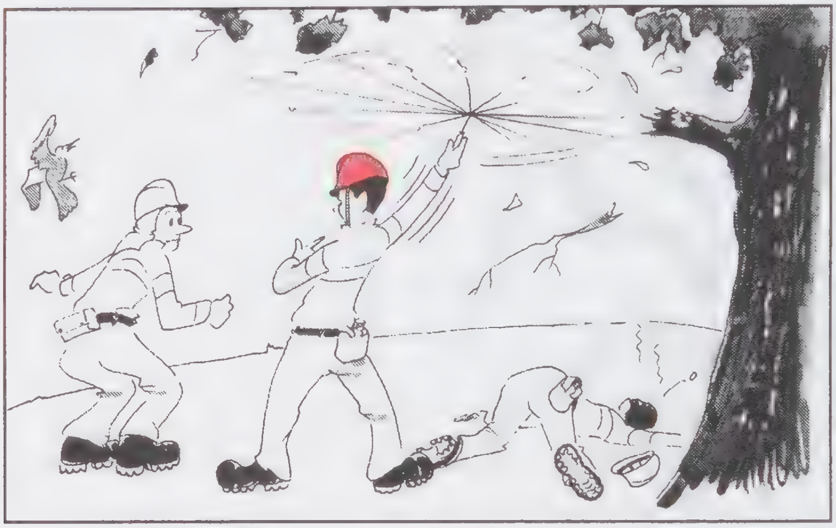


Figure 2.69 This fire officer will have many replacement psychrometers in his career.

You may have to establish a "weather watch." This may be a lookout or a firefighter.

If there is a possibility that the weather may change, you may want to establish a security weather watch. This function should be assigned to an experienced person, who should be positioned in a strategic location in order to observe any weather changes. If there is a staffed lookout tower close by, the lookout could fill this function. If your main concern is an approaching cold front, you may want the weather observer positioned some 20 miles away from the fire, in the direction of the approaching front.

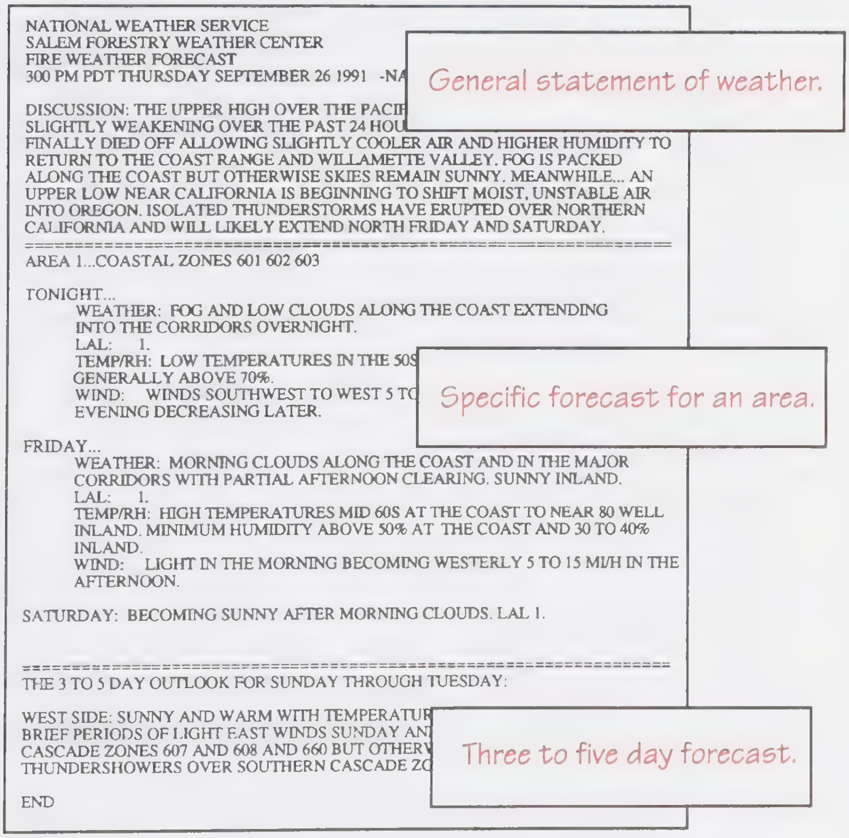
Daily Fire Weather Forecasts

Twice a day the National Weather Service prepares fire weather forecasts for fire protection agencies (Figure 2.70). Some agencies use these forecasts to plan their daily staffing patterns and activities, prevention programs, and to set dispatch levels. There are three parts to each of the forecasts: a general discussion of the weather, a forecast for a specific zone, and a five day outlook. The primary forecast is given in the afternoon for the next day. A revised forecast is given about 1000 hours the next day, based on data received in the morning.

Listen carefully to the weather forecast; learn what all of the terms mean.

Give thought to how the forecast may impact your operation.

GENERAL FIRE WEATHER FORECAST



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NATIONAL WEATHER SERVICE
SALEM FORESTRY WEATHER CENTER
FIRE WEATHER FORECAST
300 PM PDT THURSDAY SEPTEMBER 26 1991   -NA

DISCUSSION: THE UPPER HIGH OVER THE PACIF
SLIGHTLY WEAKENING OVER THE PAST 24 HOU
FINALLY DIED OFF ALLOWING SLIGHTLY COOLER AIR AND HIGHER HUMIDITY TO
RETURN TO THE COAST RANGE AND WILLAMETTE VALLEY. FOG IS PACKED
ALONG THE COAST BUT OTHERWISE SKIES REMAIN SUNNY. MEANWHILE... AN
UPPER LOW NEAR CALIFORNIA IS BEGINNING TO SHIFT MOIST, UNSTABLE AIR
INTO OREGON. ISOLATED THUNDERSTORMS HAVE ERUPTED OVER NORTHERN
CALIFORNIA AND WILL LIKELY EXTEND NORTH FRIDAY AND SATURDAY.
================================================================
AREA 1...COASTAL ZONES 601 602 603

TONIGHT...
        WEATHER:  FOG AND LOW CLOUDS ALONG THE COAST EXTENDING
        INTO THE CORRIDORS OVERNIGHT.
        LAL:      1.
        TEMP/RH:  LOW TEMPERATURES IN THE 50S
        GENERALLY ABOVE 70%.
        WIND:     WINDS SOUTHWEST TO WEST 5 TO
        EVENING DECREASING LATER.

FRIDAY...
        WEATHER:  MORNING CLOUDS ALONG THE COAST AND IN THE MAJOR
        CORRIDORS WITH PARTIAL AFTERNOON CLEARING. SUNNY INLAND.
        LAL:      1.
        TEMP/RH:  HIGH TEMPERATURES MID 60S AT THE COAST TO NEAR 80 WELL
        INLAND. MINIMUM HUMIDITY ABOVE 50% AT  THE COAST AND 30 TO 40%
        INLAND.
        WIND:     LIGHT IN THE MORNING BECOMING WESTERLY 5 TO 15 MI/H IN THE
        AFTERNOON.

SATURDAY:  BECOMING SUNNY AFTER MORNING CLOUDS. LAL 1.


================================================================
THE 3 TO 5 DAY OUTLOOK FOR SUNDAY THROUGH TUESDAY:

WEST SIDE: SUNNY AND WARM WITH TEMPERATUR
BRIEF PERIODS OF LIGHT EAST WINDS SUNDAY AN
CASCADE ZONES 607 AND 608 AND 660 BUT OTHERV
THUNDERSHOWERS OVER SOUTHERN CASCADE ZO

END
```

General statement of weather.

Specific forecast for an area.

Three to five day forecast.

Figure 2.70 There are three parts to a general fire weather forecast

The forecast for each of the zones includes the:

- Predicted weather
- Temperature
- Relative humidity
- Wind speed and direction (at 20 feet)
- Lightning Activity Level (LAL)

You can get copies of this forecast from the National Weather Service or state and federal wildland fire agencies. Make it a habit to review the forecast for your area. Develop a "feel" for what is forecasted and how it fits your particular area.

Lightning Activity Level

The lightning activity level prediction provides a general forecast for lightning activity. It uses a numerical rating of 1 to 6 as described below:

Lightning Activity Level 1 - No thunderstorm activity forecasted.

Lightning Activity Level 2 - Isolated thunderstorms forecasted. Light rain will occasionally reach the ground. Lightning is very infrequent: 1 to 5 cloud-to-ground strikes in a 5 minute period.

Lightning Activity Level 3 - Widely scattered thunderstorms forecasted. Light to moderate rain will reach the ground. Lightning is infrequent: 6 to 10 cloud-to-ground strikes in a 5 minute period.

When the LAL is predicted to be 6, you may be very busy, very soon.

Lightning Activity Level 4 - Scattered thunderstorms forecasted. Moderate rain is commonly produced. Lightning is frequent: 11 to 15 cloud-to-ground strikes in a 5 minute period.

Lightning Activity Level 5 - Numerous thunderstorms forecasted. Rainfall is moderate to heavy. Lightning is frequent and intense: greater than 15 cloud-to-ground strikes in a 5 minute period.

Lightning Activity Level 6 - Widely scattered dry (no rain reaches the ground) thunderstorms forecasted. Lightning is infrequent: 6 to 10 cloud-to-ground strikes in a 5 minute period. This type of lightning has the potential to cause extreme fire activity, because of the lack of accompanying rain. An LAL of 6 is normally highlighted in the fire weather forecast with a Red Flag Warning.

Common Forecast Terms

Weather forecasters use specific terms to address the probability of precipitation (the likelihood of rain), area qualifiers (the amount of area involved), precipitation intensity (how hard it will rain), precipitation duration (how long it will rain), and sky condition or cloud cover (sunny or cloudy) (Figure 2.71). You should be familiar with these terms so that you can understand what the forecast means.

Red Flag Watches and Warnings

Red Flag Watches or Warnings are "posted" when the fire weather forecaster wants to call attention to some weather phenomenon that may or will increase fire danger in a significant way (Figure 2.72). Normally these alerts are given for a specific period of time. These warnings should be taken very seriously. It is a given that weather forecasting is not an "exact science," but to ignore a Red Flag Watch or Warning may be a disastrous mistake!

There are specific criteria that trigger a Red Flag Watch or Warning:

- Dry lightning is predicted.
- Lightning is predicted after a period of extremely dry weather.
- Unusually low relative humidity.
- Very dry and unstable air (a high Haines Index).
- Very strong and shifting winds which may or may not be associated with the passage of a cold front.

A Red Flag Watch is an alert to the possibility that one or more of these factors may occur in the near future. A Red Flag Warning is used to warn of an impending or ongoing red flag event. A Watch is normally issued before a Warning. These warnings are not issued lightly. Never let yourself become complacent about them.

Red flag Watches and Warnings are not issued casually. They should "scare you" a little. Take each one very seriously.

Spot Weather Forecast

A spot weather forecast is for an individual fire, event or site given for a specific period of time. They are much more detailed, timely and specific than the general forecast. They take into

TERMS USED IN WEATHER FORECASTS

Probability of Precipitation (POP) What are the chances it will rain?

slight chance	10 to 20% chance
chance	30 to 40% chance
good chance	50% chance
likely	60 to 70% chance
no qualifying remark	80% or greater chance

Area Qualifiers What areas will be involved?

isolated or few	less than 15% of the area
widely scattered	15 to 24% of the area
scattered	25 to 54% of the area
numerous or widespread	55 to 74% of the area
no qualifying remark	75% or greater of the area

Precipitation Intensity How hard will it rain?

very light	less than 0.01-inch per hour
light	less than 0.1-inch per hour
moderate	0.1 to 0.3-inch per hour
heavy	greater than 0.3-inch per hour

Precipitation Duration How long will it rain?

brief	of short duration
occasional	occurring at irregular intervals
intermittent	occurring at periodic intervals
frequent	occurring quite often, at close intervals

Sky Conditions and Cloud Cover Will it be cloudy or sunny?

cloudy	90 to 100% opaque cloud cover
mostly cloudy	70 to 80% cloud cover
partly cloudy	30 to 60% cloud cover
mostly sunny	10 to 30% cloud cover
sunny	less than 10% cloud cover
fair	less than 40% opaque clouds
variable cloudiness	used to show that cloudiness will increase/decrease several times during forecast period

Figure 2.71 Common terms used in weather forecasts.

consideration local topographic effects and weather features of a very small area. To get the most accurate forecast possible, you will have to give as much "local" weather data as you can gather.

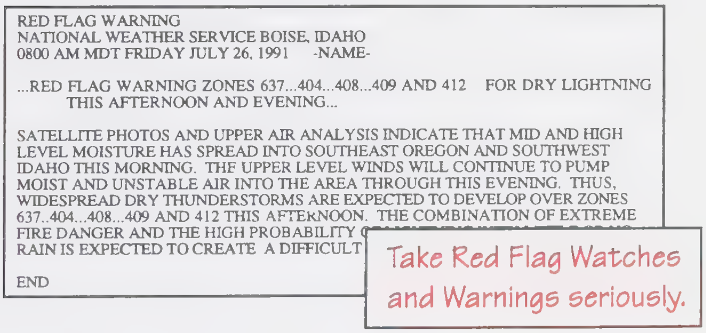
You should consider requesting a spot weather forecast when:

- The general fire weather forecast does not seem to fit your situation.
- Indicators suggest possible severe burning conditions.
- Control is not expected for several days.
- A Red flag Warning is in effect for the area.
- There is, or has been, erratic fire behavior.
- The fire is in, or is moving into, flashy, moderate to heavy fuels.

If you think you need an updated forecast, ask for a spot forecast.

Changing weather factors are what cause the day-to-day changes in fire behavior. Knowing and understanding how these changes will impact you and your firefighters is mandatory. Your success as a fire officer, not to mention your life, depends on it!

EXAMPLE OF A RED FLAG WARNING



RED FLAG WARNING
NATIONAL WEATHER SERVICE BOISE, IDAHO
0800 AM MDT FRIDAY JULY 26, 1991 -NAME-

...RED FLAG WARNING ZONES 637...404...408...409 AND 412 FOR DRY LIGHTNING
THIS AFTERNOON AND EVENING...

SATELLITE PHOTOS AND UPPER AIR ANALYSIS INDICATE THAT MID AND HIGH
LEVEL MOISTURE HAS SPREAD INTO SOUTHEAST OREGON AND SOUTHWEST
IDAHO THIS MORNING. THE UPPER LEVEL WINDS WILL CONTINUE TO PUMP
MOIST AND UNSTABLE AIR INTO THE AREA THROUGH THIS EVENING. THUS,
WIDESPREAD DRY THUNDERSTORMS ARE EXPECTED TO DEVELOP OVER ZONES
637..404...408...409 AND 412 THIS AFTERNOON. THE COMBINATION OF EXTREME
FIRE DANGER AND THE HIGH PROBABILITY
RAIN IS EXPECTED TO CREATE A DIFFICULT

END

Take Red Flag Watches and Warnings seriously.

Figure 2.72 Red Flag Watches or Warnings are usually short, concise, alerts for a specific period of time. Take them seriously. Your life may depend on it.

Notes:

3

Topography and Fuels

In this chapter, you'll

- *Learn how topography and fuels impact fire behavior.*
- *Gain an appreciation for the influence of aspect and slope on fire behavior.*
- *Learn the relationships between fuel size, shape and moisture and their impact on fire behavior.*
- *Learn why fuel moisture is the one factor that affects all fire behavior characteristics.*
- *Learn the stages of vegetative development.*
- *Read about the factors which control fuel moisture content.*
- *Learn to predict potential changes in fuel moisture content on the fireground.*

"Fuels were extremely dry...(with) a significant oak leaf litter drop...(these) helped to generate plume-dominated fire behavior..." Clark Seely comments regarding the fatal fire burnover on the Hull Mountain Fire.

"The place where the fatality occurred was topographically moderate...However, the configuration of neighboring ridges helped to direct intense activity at the area where the fatality occurred."

Wildfire Magazine, Vol. 4, No. 2, June 1995, with ref. to the South Canyon Fire.

Like the weather, topography and fuels have a direct bearing on fire behavior. However, unlike weather, the basic characteristics of topography and fuels don't change. Yet, the effect of topography and fuels will vary in response to other factors. For instance, fire behavior in canyons or on ridges will change depending on wind speed and direction, or on the relationship of these features to one another. The same fuel located in different areas will burn differently depending on the amount and angle of solar radiation reaching it, as well as the relative humidity in the atmosphere.

It is essential that you understand how weather and other factors can cause a fire to behave differently even within the same topographical area and fuel environment. The potential impact of these changes should be incorporated into your strategy and tactics.

Topography

As noted above, the topography of an area is generally considered a fixed and known factor in firefighting. The variables occur with respect to where the fire is at any particular time, be it in a box canyon or on a south-facing slope. Topography has a direct bearing on how much solar radiation is absorbed by the surface of the earth, because it determines the angle at which solar radiation strikes the surface. This in turn modifies the microclimate which influences the type of vegetation (or fuel) in the area. These factors should be considered when deciding when and where to fight a fire.

Topography has a direct bearing on how much solar radiation reaches the earth's surface.

The Effect of Elevation on Fuels

The elevation or altitude of a site also has a direct impact on how a fire will act and burn. This is because weather and elevation have such a great effect on the type and availability of fuel (Figure 3.1). Elevation affects the:

- Amount of precipitation received - The higher elevations normally receive less precipitation. However, snow stays on the ground longer at higher elevations because the mean temperature is lower.
- Fuel types and loading - There is normally less fuel at higher elevations. This is mainly due to the fact that there is less soil, less moisture, and the temperatures are cooler.
- Curing dates of vegetation - Fuels at higher elevations cure later than those at lower elevations.
- Length of fire season and general fire danger - The fire season and fire danger is shorter and less intense at higher elevations for all the reasons listed above.

Elevation has an impact on how a fire will burn.

Position on a Slope

Position on a slope also has an effect on fuel availability. There is usually more fuel at base and midslope sites than on the top of a ridge because of greater variations in temperature and relative humidity. This has a direct impact on the potential size of fires. More fires will burn over 10 acres if they start at the base of a slope than if they started midslope. One reason is because there is normally more fuel available at the base of a slope (Figure 3.2).

If a fire starts at the bottom of a slope it has a greater chance of being larger than one that starts further up the slope.

Aspect

Aspect is the direction a slope is facing. The orientation of a slope to the sun has a direct bearing on the amount of solar radiation that reaches the surface. Although the aspect is fixed, the

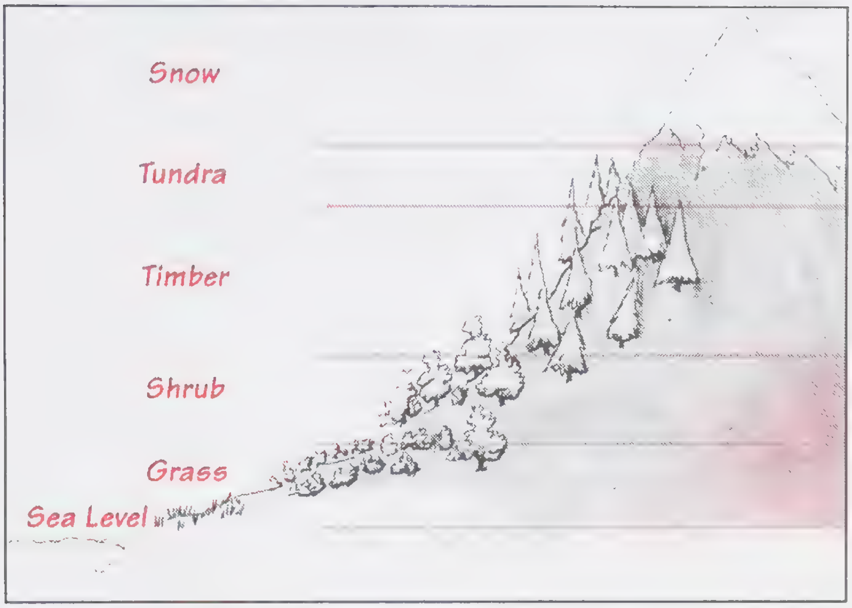

Snow
Tundra
Timber
Shrub
Grass
Sea Level

Figure 3.1 Elevation has a direct effect on the type and availability of fuel.

Higher elevations normally receive less precipitation.

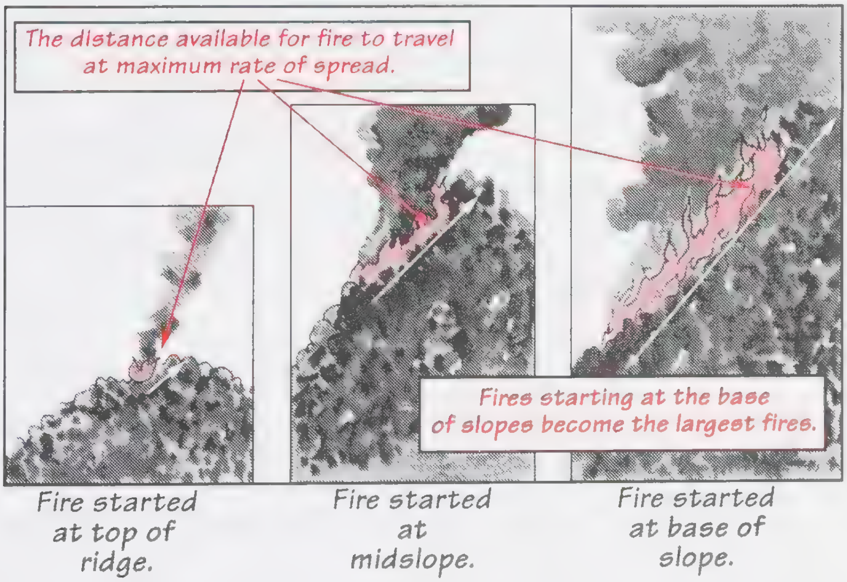

The distance available for fire to travel at maximum rate of spread.
Fires starting at the base of slopes become the largest fires.
Fire started at top of ridge.
Fire started at midslope.
Fire started at base of slope.

Figure 3.2 Fires starting at the base of slopes become the largest fires.

Fires starting at the base of the slope have more fuel available to it in which to burn.

amount of solar radiation received varies with the position of the sun; therefore, the impact of aspect on fire behavior changes throughout the day.

The amount and type of fuel available varies greatly depending on aspect.

Northern aspects usually have heavier fuels.

Northern Aspects - On slopes facing north you normally find heavier fuels with high moisture content. These sites also have the lowest average temperatures, lowest rate of spread, latest curing dates, and last areas of snow melt.

Eastern aspects heat earlier in the day.

Eastern Aspects - The fuels on slopes facing east are usually transitional, moving between those found on northern slopes and those found on southern slopes. Surface heating occurs earlier in the day because these slopes are the first to receive solar radiation. They are also the first to cool in the afternoon. Eastern slopes are normally on the lee, or facing away from the general wind direction.

Southern aspects usually have lighter and flashier fuels.

Southern Aspect - The fuels on southern slopes usually have the lighter and flashier fuels with the lowest moisture content. This is primarily because they receive the highest levels of solar radiation and therefore have the highest average temperatures. Fires on these aspects generally have the fastest rate of spread. Snow is gone from south facing slopes first, and fuels cure earlier in the fire season.

Western aspects are similar to southern aspects.

Western Aspect - The fuels on a west facing slope are transitional between the light fuels of southern slopes and the heavier fuels on northern slopes. Surface heating occurs in the afternoon and cooling begins later in the day. Westerly slopes are generally on the windward side of a mountain.

South and southwest aspects are the most vulnerable to fire. This is due to the fact that the fuels are usually lighter (easier to ignite), flashy (contributing to a faster burn rate), and warmer (again, easier to ignite). Winds from the southwest are usually hot and dry, with lower relative humidities.

Time of day and aspect influence the flammability of the fuels.

The time of day and aspect influence the flammability of the fuels (Figure 3.3). In general, the period when a south facing slope will burn best is very predictable. If you are fighting fire on a southern slope in the early afternoon of a hot summer day, you have all the ingredients for a major run or "blow up" of the fire.

Slope Impact on Rate of Spread

The slope on which a fire is burning is a major factor in the rate of spread (Figure 3.4). Slope contributes to preheating and

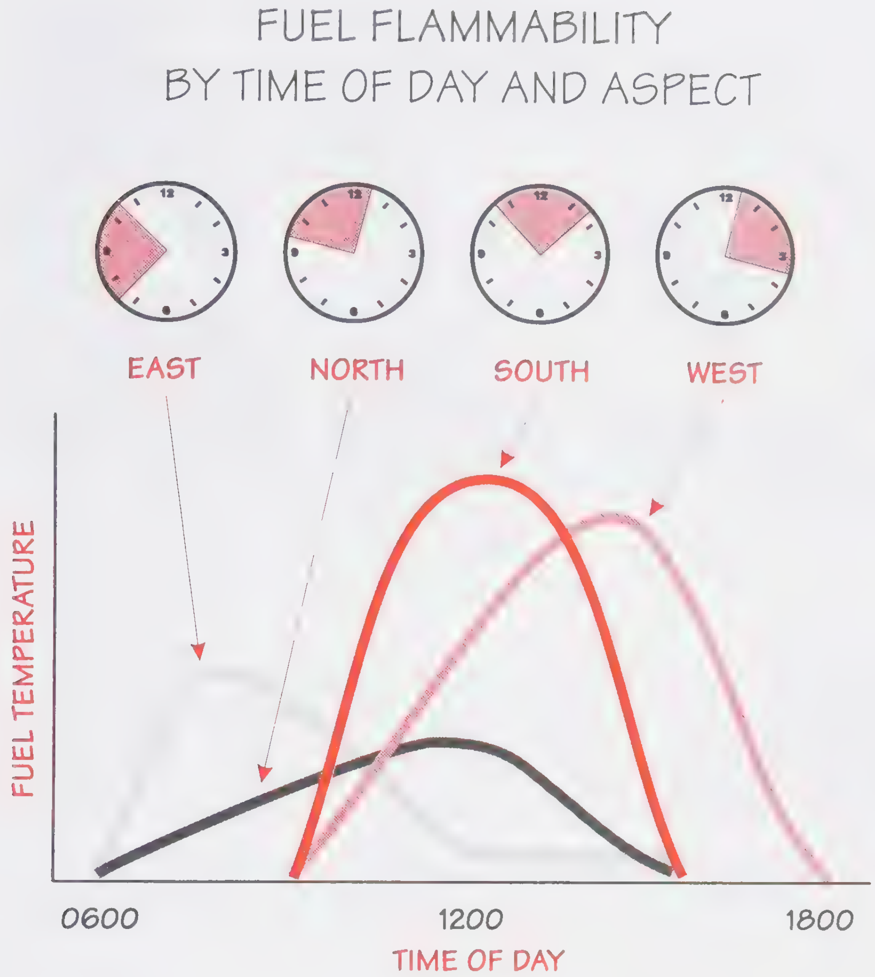


Figure 3.3 Flammability of fuels by time of day and aspect.

Fighting fire on a south or west facing slope in the afternoon can be extremely dangerous.

ignition by "presenting the fuels" to a flame front. In the absence of a wind, flames and heat will rise straight up. Slope, in effect, lifts the fuels to a position that places them closer to the flame, increasing the level of heating and making them easier to ignite. Conversely, the fuels on the downhill side of the flame are further away from heat, because the falling slope puts the fuels below the flame. The steeper the slope, the closer the fuels are to the flame, and therefore the faster the rate of spread and the narrower the flame front.

Slope and wind affect the flame-fuel relationship by moving the flame closer to or further away from the fuels.

Another problem associated with slopes is that burning materials can roll downhill, thus contributing to the spread of the fire and endangering firefighters below. This becomes an even greater concern as the fuels get heavier or the slopes become steeper.

Slope has a major impact on fire behavior.

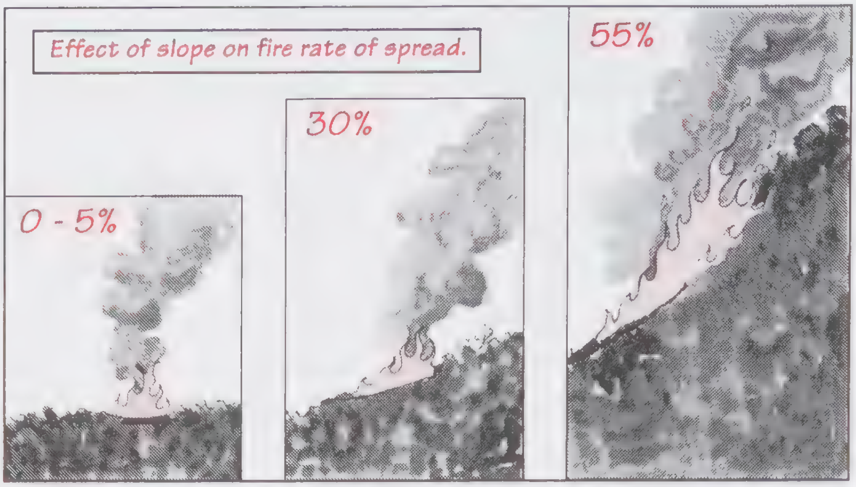

Effect of slope on fire rate of spread.
0 - 5%
30%
55%

Figure 3.4 Slopes can play a significant role in the rate of spread of a fire. They allow for the preheating and easy ignition of fuels when a fire is burning upslope.

Slope reversal will affect the rate of spread.

Slope reversal is when a fire burns to a point where the slope changes, such as the top of a ridge or the bottom of a canyon. At either of these points the rate of spread will usually change. If a fire burns up a slope and hits the top of a ridge, it usually slows as it begins to back down the other side. Conversely, when a backing fire crosses the bottom of a canyon, it usually picks up speed as it runs up the other side of the canyon.

Ridges

Ridge lines provide a break between slopes. They are one of the best places to construct fireline in steep country. When a fire burns to the ridge line, it encounters an opposing slope and possibly an opposing wind. The change in slope slows the spread (Figure 3.5). If an opposing wind is present, it may reduce the level of spotting. However, if there are converging winds along a ridge line the winds can be erratic and spotting may become a problem.

Winds on ridge tops can be erratic.

Canyons and Chimneys

Narrow canyons and intersecting drainages are always difficult and dangerous sites to fight fire. Canyons have a tendency to funnel and accelerate winds (Figure 3.6). During the heat of the day, winds are drawn up canyons and draws, much like the action of a chimney over a fireplace. As the heated air moves up and out of the canyon, it draws more air in through the mouth of the canyon. When these winds cross openings to drainages they develop eddies and other erratic conditions.

The narrowness of a canyon increases the potential for preheating, spotting and ignition on the opposite slope. Couple this with the potential for erratic wind and you can see that a narrow canyon is usually not the location of choice to attempt to fight fire.

Chimneys have been involved in the injury or death of many firefighters. A chimney is a steep, narrow chute canyon. This is one of the places where the combination of topography, weather and fuel can really create havoc. First, normal upslope air is funneled and accelerated in a chimney. If the air is unstable and surface heating is moving the wind upslope, more air is drawn into the base of the canyon. The greater air flow spreads the fire even faster and increases the likelihood of spotting. The narrowness of a chimney allows a fire burning within it to preheat the fuels more quickly, again increasing the rate of spread. If the type and quantity of fuels is conducive to a rapidly spreading fire, it will race up a chimney faster than firefighters can escape.

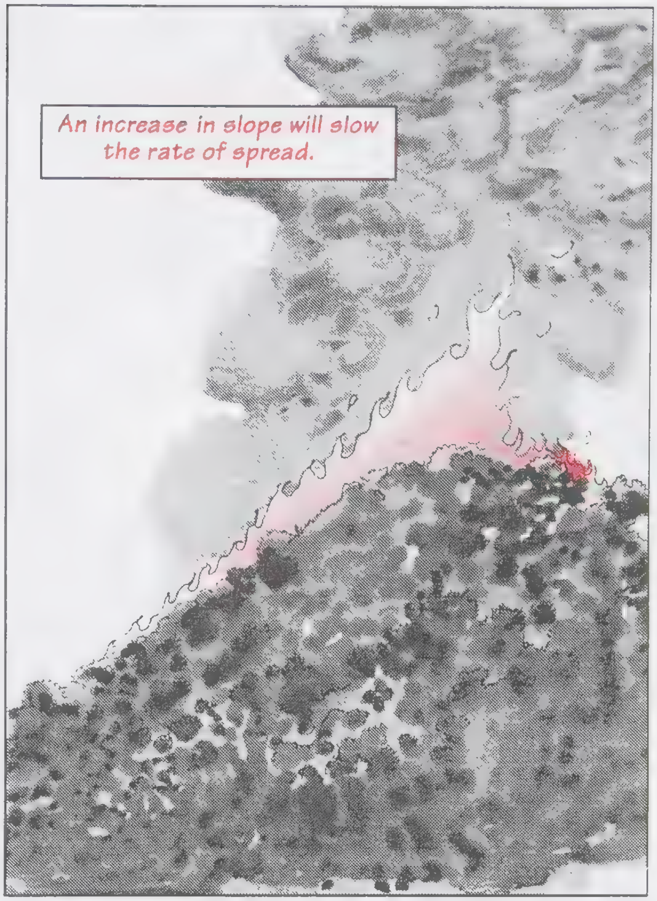

An increase in slope will slow the rate of spread.

Figure 3.5 Ridges affect the rate of spread. They are usually good places to construct fireline.

Narrow canyons increase the potential for preheating and spotting.

Barriers

A barrier is a break in the fuel, or change in fuel type or condition (fuel moisture and/or density), that can slow or stop the spread of a wildland fire. Barriers can be natural or man-made. Use barriers in the development of your plan; they may save you time and money. Some of the more common barriers are:

Use natural barriers as fuel breaks whenever you can.

Rocks or bare soil conditions - Rock outcroppings, bluffs, and bare patches of land may provide adequate barriers.

Lakes, streams, and moist soil situations - Use lakes for barriers when you can. Streams may prove to be adequate barriers

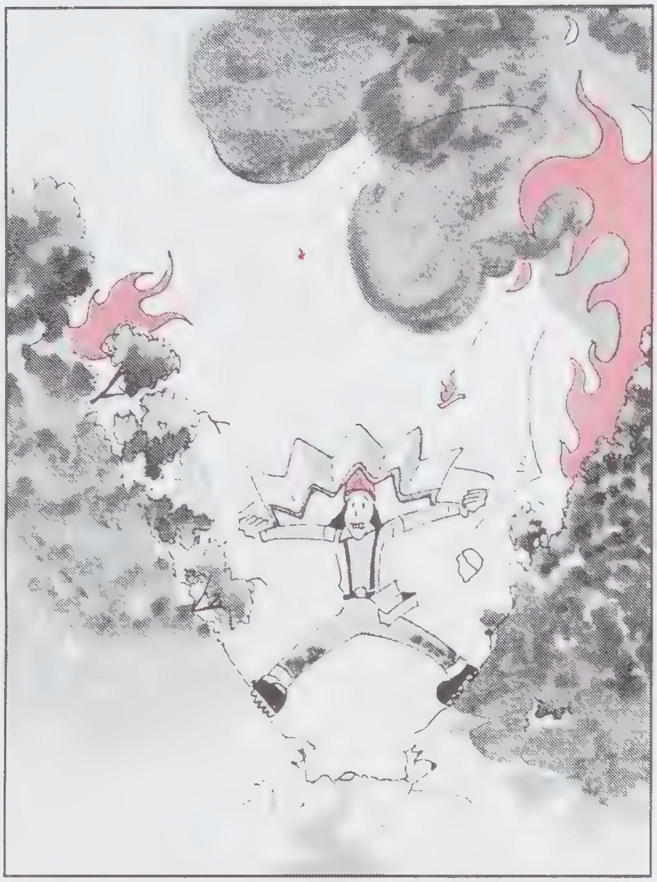


Figure 3.6 Canyons are not the best location to try to fight fire.

on flanks and during periods of moderate fire behavior.

Roads, trails, and other improvements - It is a common practice to use man-made barriers for control lines. You can "fire" from roads and trails, or use orchards and vineyards as barriers.

Change in fuel type and fuel moisture conditions - Fighting fire in light fuels is usually more effective than fighting fire in heavy fuels. Some fuel conditions may act as partial barriers. In the morning hours, lighter fuels may have a high moisture content and resist combustion. This condition may be considered a partial barrier if "used" during the morning hours.

Old burns - Previously burned areas usually provide a beneficial change in fuel types. Use them if it is to your advantage.

Fuels

The type, amount and condition of the fuels is one of the most important factors to evaluate in the devel-

Chimneys can be killers.

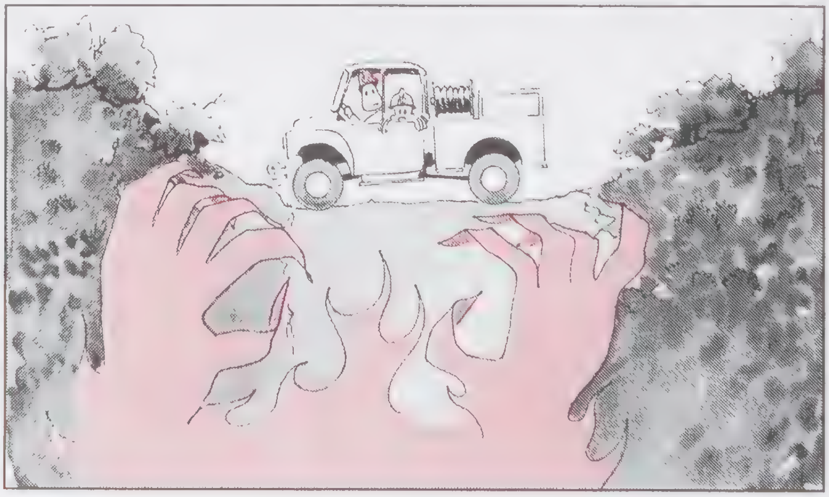


Figure 3.7 Chimneys can be deadly. Fuels are preheated more effectively and the wind is funneled by the shape of the topography.

opment of your plan to attack and control a wildland fire. Fuels vary in type (grass, brush, timber, slash, etc.), in amount (from 300 pounds to 300 tons of fuel per acre), and in condition (completely dry to soaking wet). These factors, along with the topography and weather, will be the basis of your fire behavior prediction.

Fuels are very important factors to consider in the development of your strategies and tactics.

Fuels can be divided into three groups or levels: ground fuels, surface fuels, and aerial fuels. Each of these fuel levels has an impact on the ease of ignition and the combustibility of the fuels.

Ground Fuels - Deep duff, roots, and rotten buried logs are considered ground fuels (Figure 3.8). Ground fuels do not usually play a major role in fire behavior because most burn with low intensity. However, don't be fooled into thinking that they can't be a significant problem. Roots can carry fire under constructed firelines, and ground fuels can hold fire through the winter, even under a blanket of snow. These factors should be considered when constructing fireline.

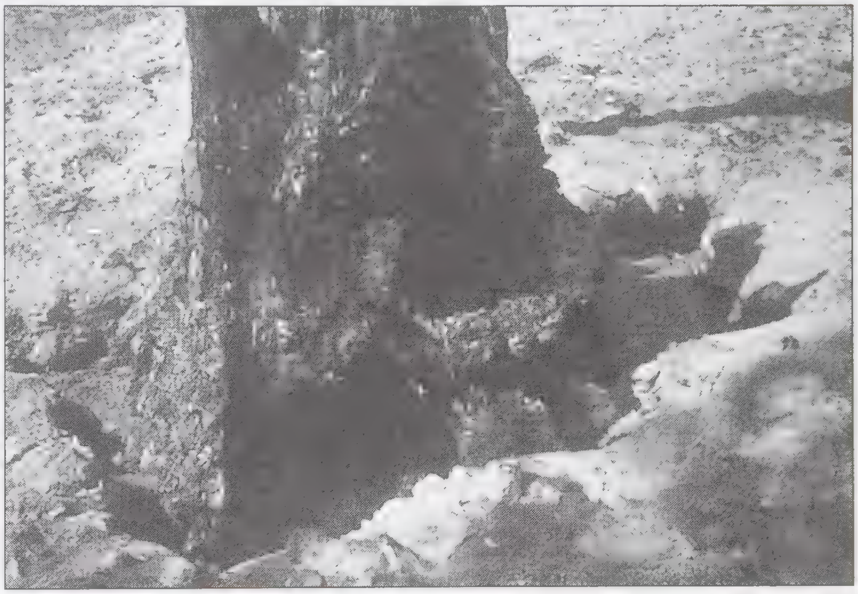


Figure 3.8 Ground fuels may just smolder, or burn with low intensity. However, they can hold fire for months.

Surface Fuels - Grass, forest litter, and brush up to about six feet in height are considered surface fuels. Surface fuels are where fires usually start. They are responsible for most fire spread and for "carrying fire" to the aerial fuels. Surface fuels are often responsible for faster rates of spread (Figure 3.9).

Aerial fuels are those over six feet tall.

Aerial Fuels - Aerial fuels are those fuels that are six feet or more in height. This includes limbs, leaves, trunks, and crowns of heavy brush and timber. The "tightness" of the aerial fuel canopy plays a role in how a fire burns. If the canopy is closed, very little solar radiation penetrates to the ground. This condition holds

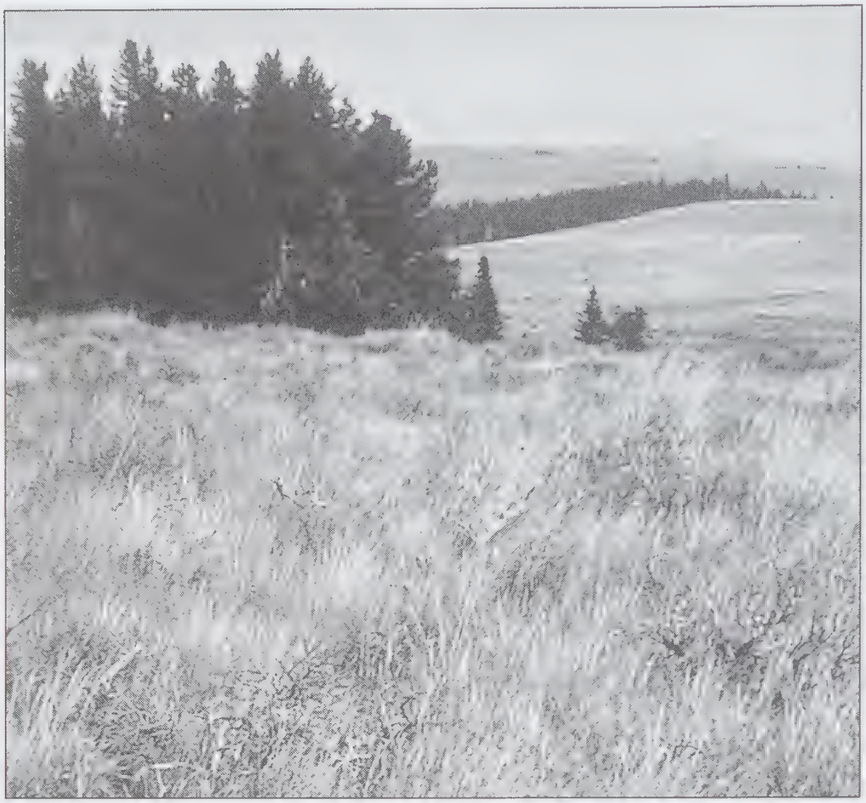


Figure 3.9 *Grass and light brush under six feet in height are considered ground fuels.*

Grass or other surface fuels are responsible for most of the fire's spread.

down the fire intensity because the surface fuels are not dried by direct solar radiation, and fuel moisture tends to be higher. But, if weather conditions and the surface fire are generating sufficient heat, a closed canopy increases the likelihood that the fire will move into the canopy and begin to crown (Figures 3.10 through 3.14).

The characteristics of the fuel controls how it will burn.

Fuel Characteristics

The characteristics of the fuel affect the way it will ignite and burn. If the fuel is large, it takes considerably more heat to get it burning. But, if a large "chunk" of fuel is burning it will also take a lot more effort to put it out. There are seven fuel characteristics that control fire behavior in different ways: compactness, loading, horizontal continuity, vertical arrangement, chemical content, size and shape, and moisture content (Figure 3.15).

Wildland fuel loading ranges from 1 to 3 tons per acre in grass, to over 200 tons per acre in timber.

Fuel loading is the dry weight of a fuel (live or dead) in a given area. Fuel loading varies greatly by fuel type and by area,

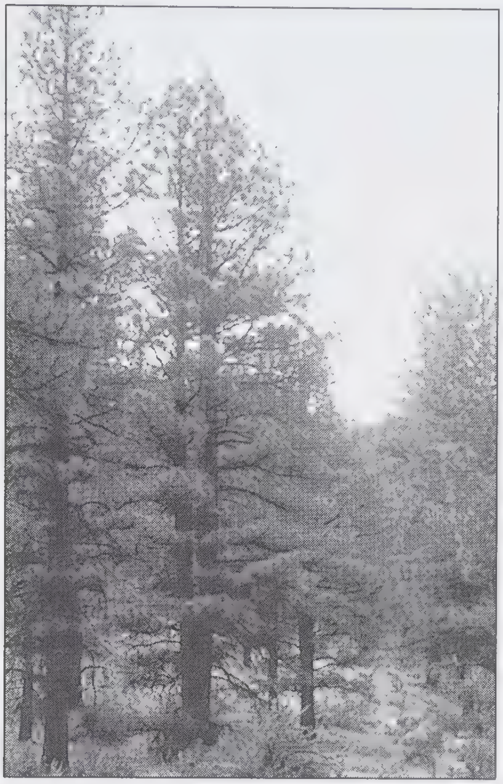


Figure 3.10 Aerial fuels are those six feet or more in height. This forest stand is considered to have an open canopy; considerable solar radiation can reach the surface fuels and air can circulate freely.

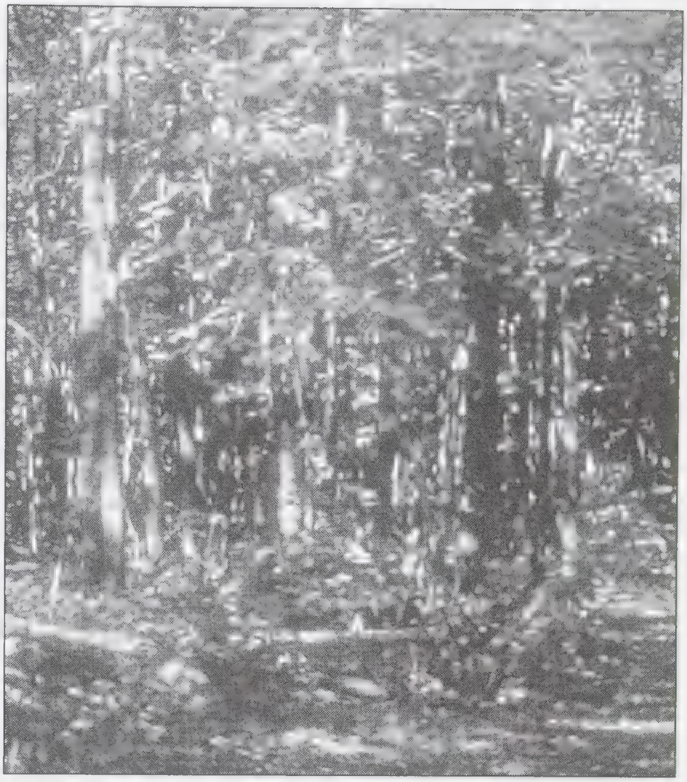


Figure 3.11 This is considered a closed canopy. Very little solar radiation will be able to penetrate the canopy and reach the surface fuels. However, if there is sufficient heat generated by a surface fire, it will move into the canopy with relative ease.

ranging from pounds to hundreds of tons per acre. Grass fuels can range from less than 1 ton up to 3 tons per acre. Brush and other shrub areas can range from 2 to 80 tons per acre. Timber litter can range from 4 to 12 tons per acre, and timber logging slash can range from 10 to 200 tons per acre. The total fuel loading in an area can be much higher than these figures, but some may not be available to carry the fire (e.g. large diameter tree trunks).

Your main concern should be the state of the dead fuels 3 inches or less and live fuels under ¼ inch in diameter.

As a fire officer, your main concern when developing strategy and tactics is the fuel loading that is subject to burning under the current and predicted weather conditions. These are primarily the dead surface fuels 3 inches and less in diameter, and live fuels under ¼ inch in diameter.

Fuel loading can be separated into four size classifications. The size of the fuel affects how it will respond to various forms of moisture (rain, dew and relative humidity). Size also impacts how

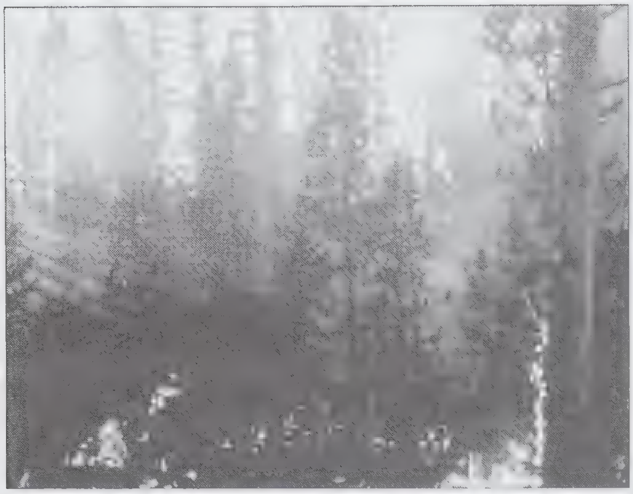


Figure 3.12 This surface fire is burning in an open canopy forest stand. It is beginning to move into the aerial fuels.

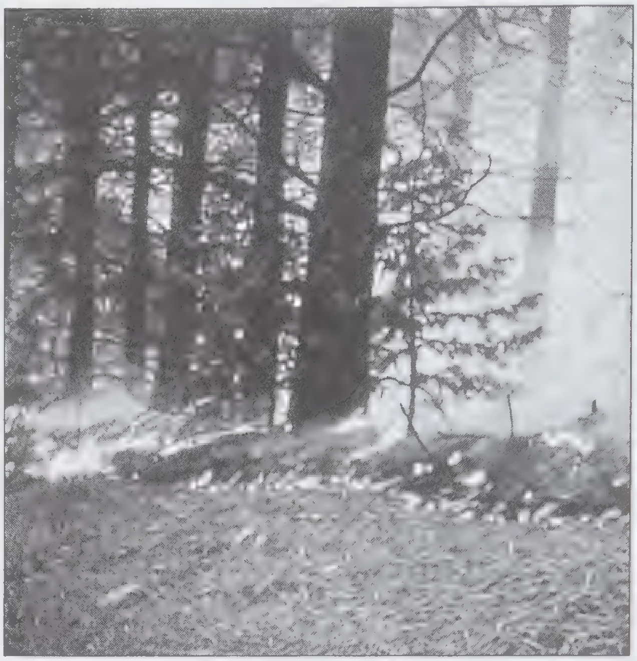


Figure 3.13 This surface fire is burning in a closed canopy forest stand. Unless weather conditions change, it probably will stay on the ground, only burning surface fuels.

quickly a dead fuel will lose moisture. The four size classifications are:

- Grasses and litter - 0 to ¼ inch in diameter (Figure 3.16).
- Twigs and small stems - ¼ to 1 inch in diameter (Figure 3.17).
- Branches - 1 to 3 inches in diameter (Figure 3.18).
- Large stems and branches - more than 3 inches in diameter (Figure 3.19).

The **size and shape of the fuel** are also critical factors in how fuels burn (Figure 3.20). The surface area-to-volume relationship is the ratio of the surface area of a fuel to its volume. The finer the fuel, the higher this ratio. The finer the fuel, the more quickly it will release its moisture and the lower the heat it will take to ignite it (Figure 3.21). Fine fuels (grasses) and flat fuels (leaves) have a greater surface area-to-volume ratio than larger fuels, like logs.

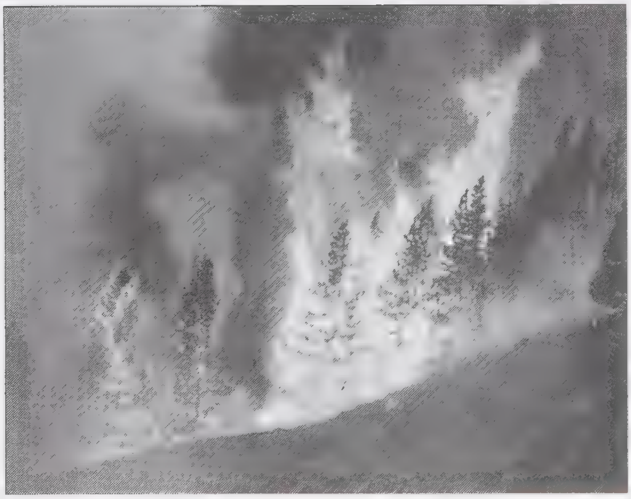


Figure 3.14 This is a crown fire. This type of fire doesn't occur very often, but when it does it can be very dangerous and spectacular.

How the seven fuel characteristics affect fire behavior.

	Fire Behavior Components					
	IGNITION	SPREAD	INTENSITY	SPOTTING	TORCHING	CROWNING
Compactness	X	X	X			
Loading	X	X	X		X	
Horizontal Continuity		X		X		X
Vertical Arrangement				X	X	X
Chemical Content	X	X	X			
Size and Shape	X	X	X	X		
Moisture Content	X	X	X	X	X	X

Figure 3.15 The seven fuel characteristics affect fire behavior in different ways. Note how moisture content has the greatest effect on fuel behavior.

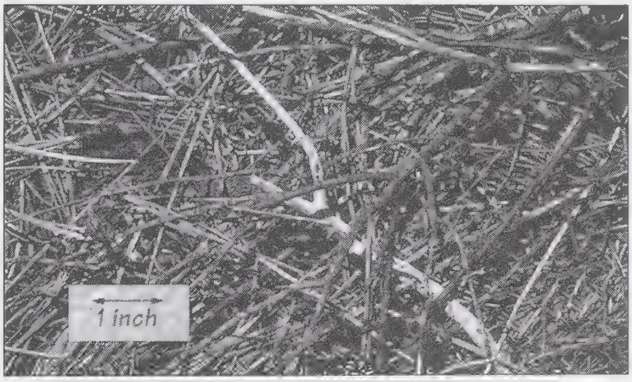


Figure 3.16 Grasses and litter range from 0 to ¼ inch in diameter.

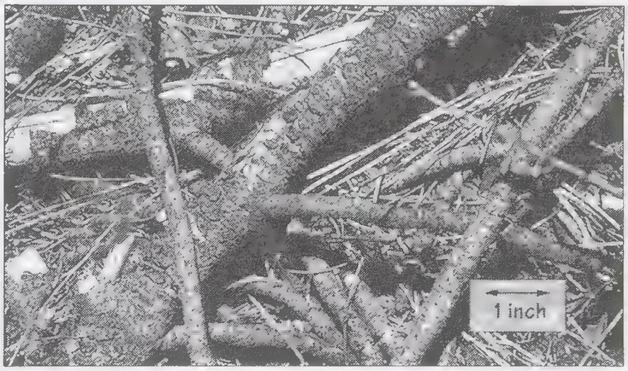


Figure 3.17 Twigs and small stems range from ¼ to 1 inch in diameter.

The size and shape of firebrands affects how much spotting will occur and over what distances. Smaller embers normally produce short-range spotting since they burn up more quickly. Cones, bark plates, pine needles, and shake shingles produce firebrands that can be lifted by convection columns and carried great distances. They also have sufficient size that they will continue to burn for longer periods (Figure 3.22). The shape of a firebrand is also important. Flat brands stay airborne longer, whereas round firebrands are more likely to roll down hillsides.

The size and shape of the fuels is also important.

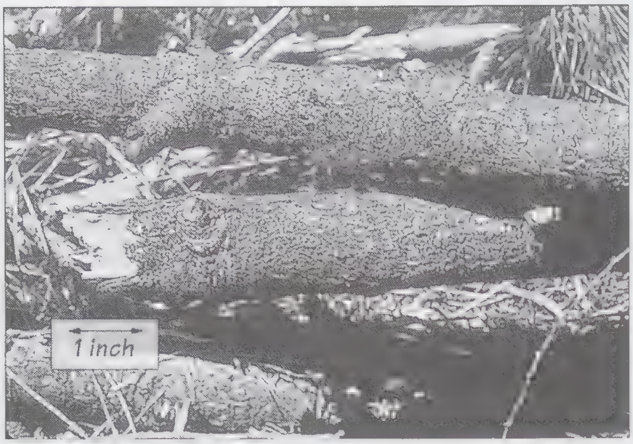


Figure 3.18 Branches range from 1 to 3 inches in diameter.

Figure 3.19 Large stems and branches are 3 inches or more in diameter.

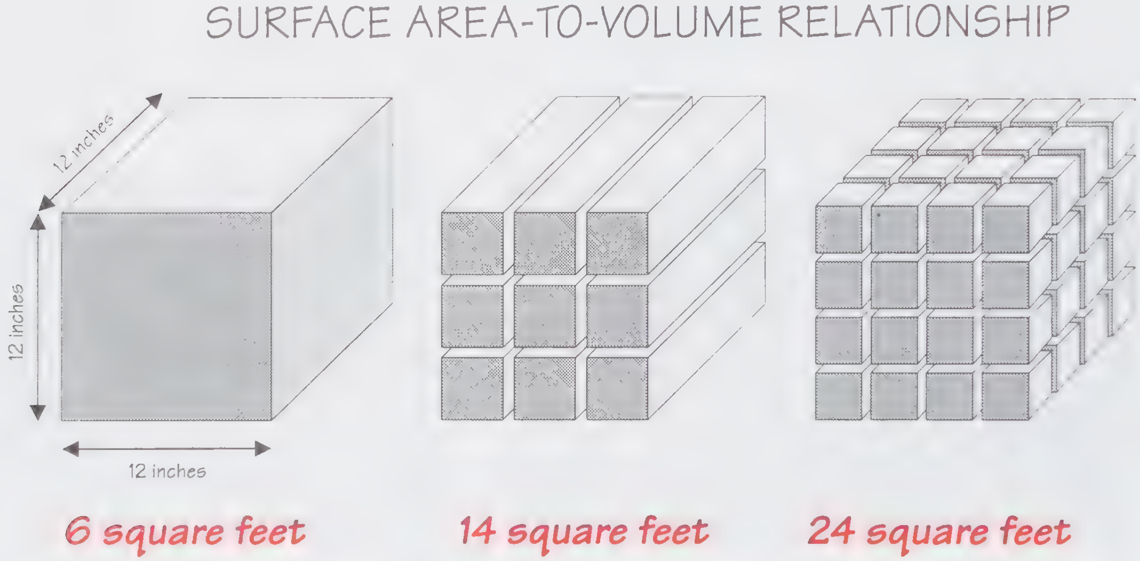

SURFACE AREA-TO-VOLUME RELATIONSHIP
12 inches
12 inches
12 inches
6 square feet
14 square feet
24 square feet

Figure 3.20 The size of a fuel has a direct relationship to the surface area. All three of these blocks have a volume of 1 cubic foot. But, because of their shape and size, the surface area varies greatly.

Compactness refers to the spacing between fuel particles. The closeness and arrangement of the fuel influences how easily it will ignite and how well it will burn. If the fuels are very compact, there is less surface area exposed to the flames and the oxygen necessary to support combustion. You can expect a slower rate of spread (Figure 3.23). Fuels that are looser in their arrangement are drier, easier to ignite, and burn with a higher rate of spread (Figure 3.24).

Fuel bed depth is the average height of the surface fuels.

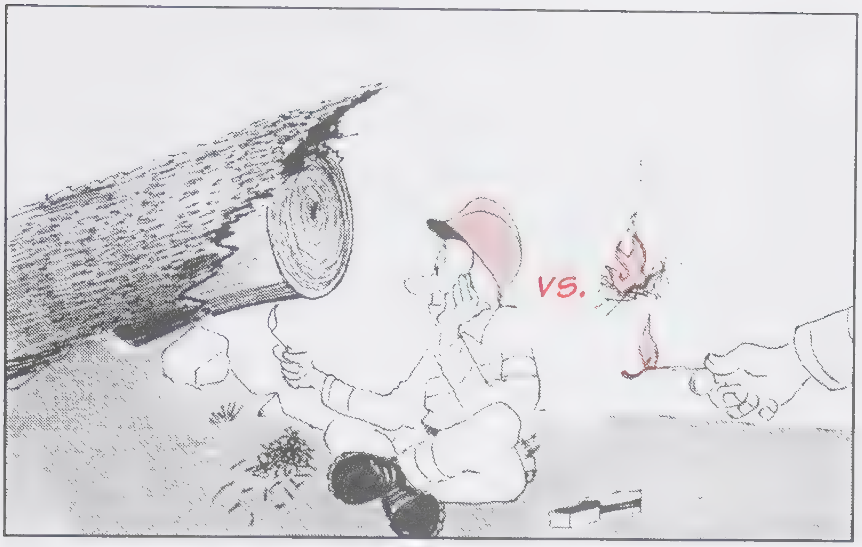


Figure 3.21 Which firefighter is going to get the campfire started first? The finer the fuel, the less heat it takes to ignite it.

There is a direct relationship between the size of the fuels and its surface area.

Figure 3.22 Firebrands can be a real problem. Their size and shape are factors that control the amount and distance of spotting.

The finer the fuel, the less heat it takes to ignite it.

Fuel bed depth is the average height of surface fuel that is available for combustion. Fuel orientation refers to the horizontal or vertical orientation of the fuel. Fuel bed depth and orientation are significant fuel properties for predicting whether a fire will ignite, as well as its rate of spread and intensity. Grasses and shrubs have a vertical orientation, and the fire intensity in this type of fuel increases with its depth. Timber litter and slash are horizontally oriented fuels and slowly increase in depth as the load increases (Figures 3.25 and 3.26).

The size and shape of fuels are factors that control the amount and distance of spotting.

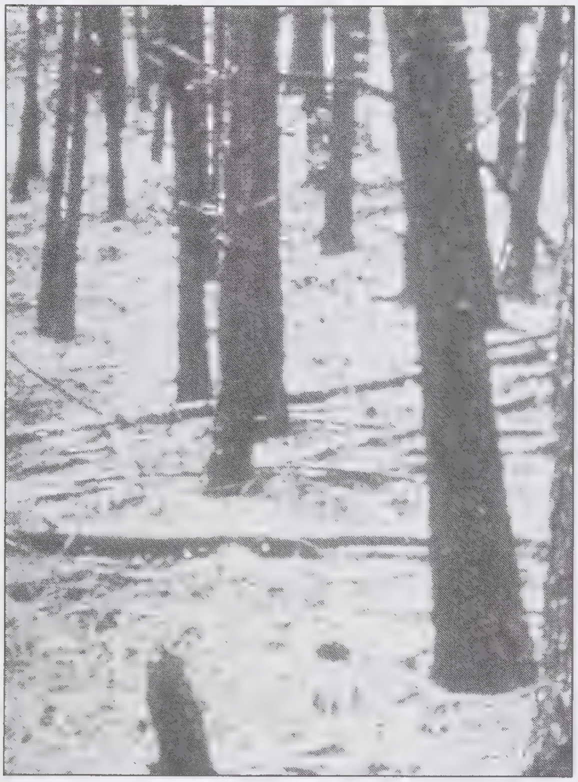


Figure 3.23 The litter in this picture is fairly compact. The rate of spread will be slower than a grass fire where the fuels are "standing," even though the fuel loading may be the same.

The **horizontal continuity** or distribution of fuels has an impact on how a fire spreads; the rate of spread; and whether the fire will move along the surface or through the crowns, or both. A fuel bed may either be continuous or patchy. If the fuels are widespread or patchy (Figure 3.27), a fire will have some difficulty moving from one "island of fuel" to another. For a fire to move rapidly through patchy fuels, it will take a strong wind moving up a steep slope. Continuous fuel beds provide available fuels at the surface and in the crowns (Figure 3.28). As a fire officer, you should be most concerned when the surface fuels are continuous.

As discussed previously, if the aerial fuels are continuous, it will affect how the surface fuels burn. A fully closed canopy may block all solar radiation from reaching the surface, hold moisture longer, and drastically reduce the amount of wind that can influence surface fires. The greater the crown closure, the

The horizontal continuity of fuels has an impact on how a fire spreads.

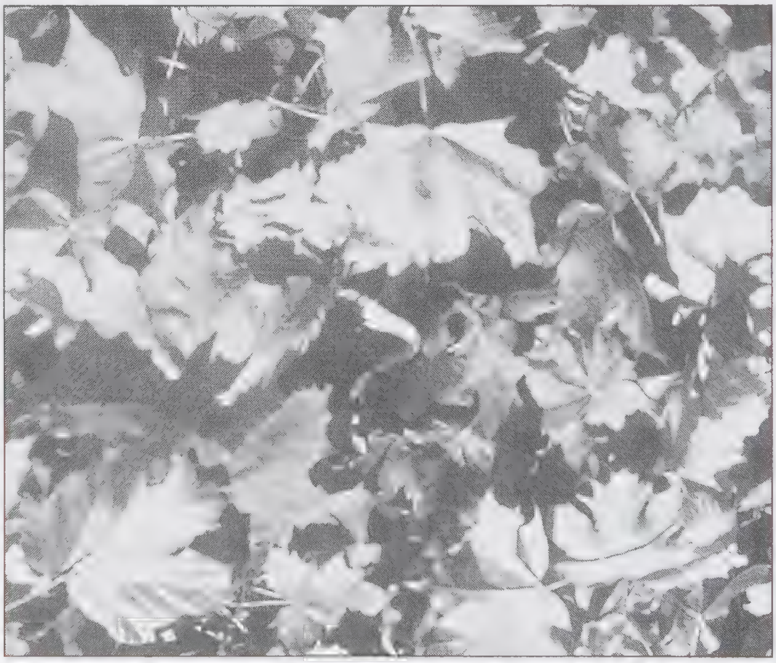


Figure 3.24 Fuels that are looser in their arrangement are easier to ignite, and burn with a higher rate of spread because there is more oxygen to support combustion.

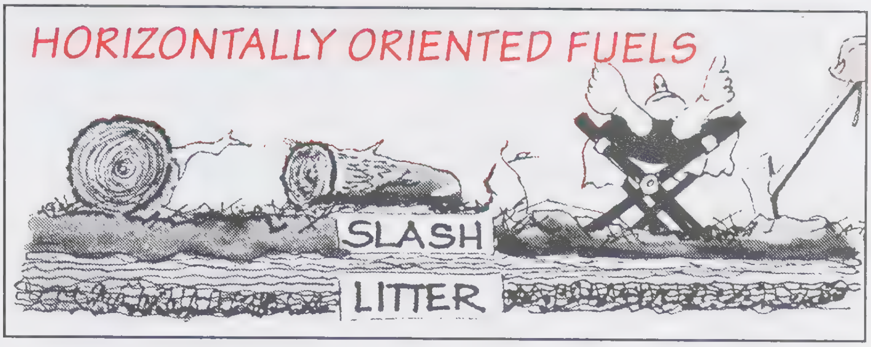


Figure 3.25 Horizontally oriented fuels include timber litter and slash.

Horizontal fuels include litter and slash.

greater the reduction in wind (Figure 3.29). Once a surface fire begins to "torch" individual trees or move into the aerial fuels, you have a completely different situation.

The **vertical arrangement** and continuity of the fuels are very important characteristics. They determine whether a fire will be able to move into the aerial fuels with ease or not. When there are fuels available for combustion throughout the vertical fuel bed, it is said that there are **ladder fuels** (Figure 3.30).

There are several strata of fuel in a mature forest stand or even in a brush field. There are surface litter and grasses. There are the low-level twigs and branches of the brush, understory shrubs and young trees. Then there is the subcanopy. The subcanopy can be the crowns of the brush or young trees, and the lower branches of mature trees. The top stratum is the canopy of the dominant trees. Fire may burn through one or more of these strata. If one or more layers are not burned, initially, it leaves fuel available to burn later if conditions change. In most cases when lower fuel levels burn, the upper fuel levels are dried out and perhaps scorched. The upper-level fuels are still able to carry fire if there is sufficient heat to ignite them.

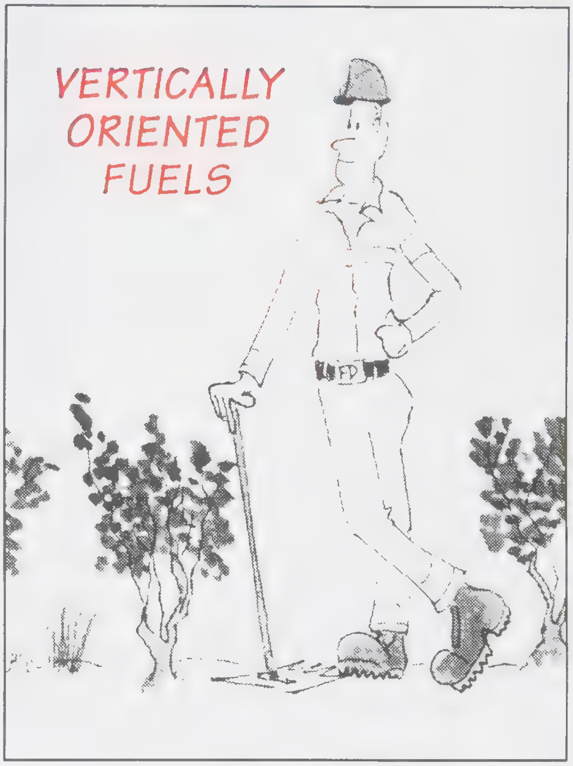


Figure 3.26 Vertically oriented fuels include grass and shrubs.

Vertically oriented fuels affect how a fire will move into the aerial fuels.

Having an environment where the fire has moved through an area and left one or more of the fuel layers available to burn can

Patchy fuels burn "best" when driven by a strong wind

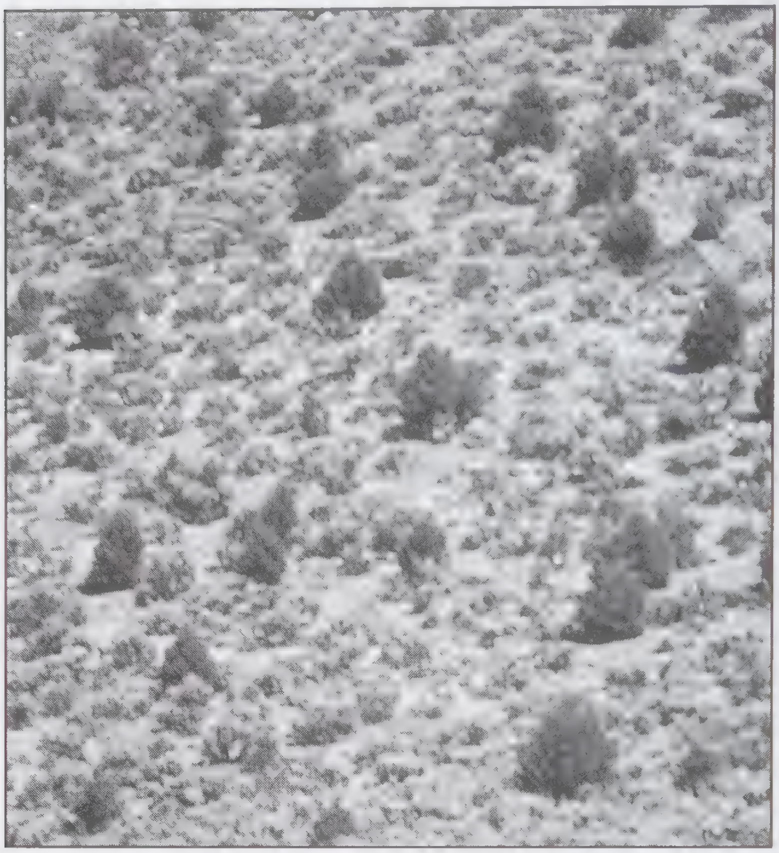


Figure 3.27 Patchy fuels burn with considerable intensity if they are driven by a strong wind or if the fire is burning up a steep slope.

If all the fuel is not consumed, a reburn is possible.

be a potentially dangerous situation. For example, if a low intensity fire moved through an area consuming the ground litter, it would dry out the fuels above it (Figure 3.31). If conditions changed later in the day, and an ignition source became available, a fire of much greater intensity could move through the area again in the higher fuel strata. This is called a **reburn**.

As a fire officer, you must concern yourself with the potential for reburns. When cutting line in an area that has not completely burned, you may think that you are making a direct attack (fighting fire right on the fire's edge), which is one of the safer strategies. But, in fact, you are making an indirect attack (fighting fire some distance from the fire's edge), because you have unburned fuel on both sides of the fireline you are constructing. This is a very dangerous scenario.

Fuel moisture content affects the potential for ignition.

Fuel **moisture content** is the amount of water in a fuel. Fuel moisture content can range from less than 5% in dried grasses to

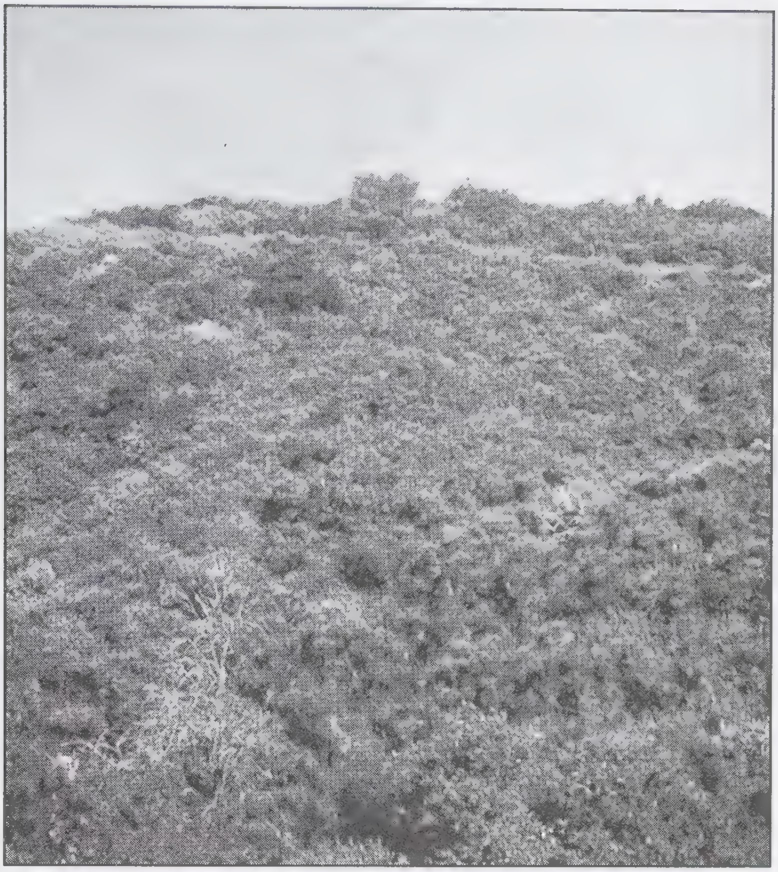


Figure 3.28 Horizontally continuous fuel beds provide an opportunity to spread fire for great distances.

Continuous fuels provide an opportunity for large fires.

300% in live fuels. How this is calculated will be explained later. Fuel moisture affects the potential for ignition and the intensity with which fuels will burn.

Fuels can take on moisture from several sources.

Fuels can take on moisture from several sources. They can pick it up from the damp soil on which they rest, from rain or dew, or from the humidity in the air. Fuels lose moisture through evaporation. Evaporation can be caused by the presence of drier air moving across the fuel; by solar heating; by a ground fire burning under it; or by convected, conducted or radiated heat from a fire (Figure 3.32). The fine fuels, those under ¼-inch in diameter, are the prime carriers of a wildland fire. They are also the fuels in which the fuel moisture can change the quickest.

Live fuels, even those with very high moisture content, can and do burn. Live fuels are frequently consumed by fire when there are enough dead, dry fuels around them to support combustion. The ratio of dead-to-live fuels is a primary factor. The

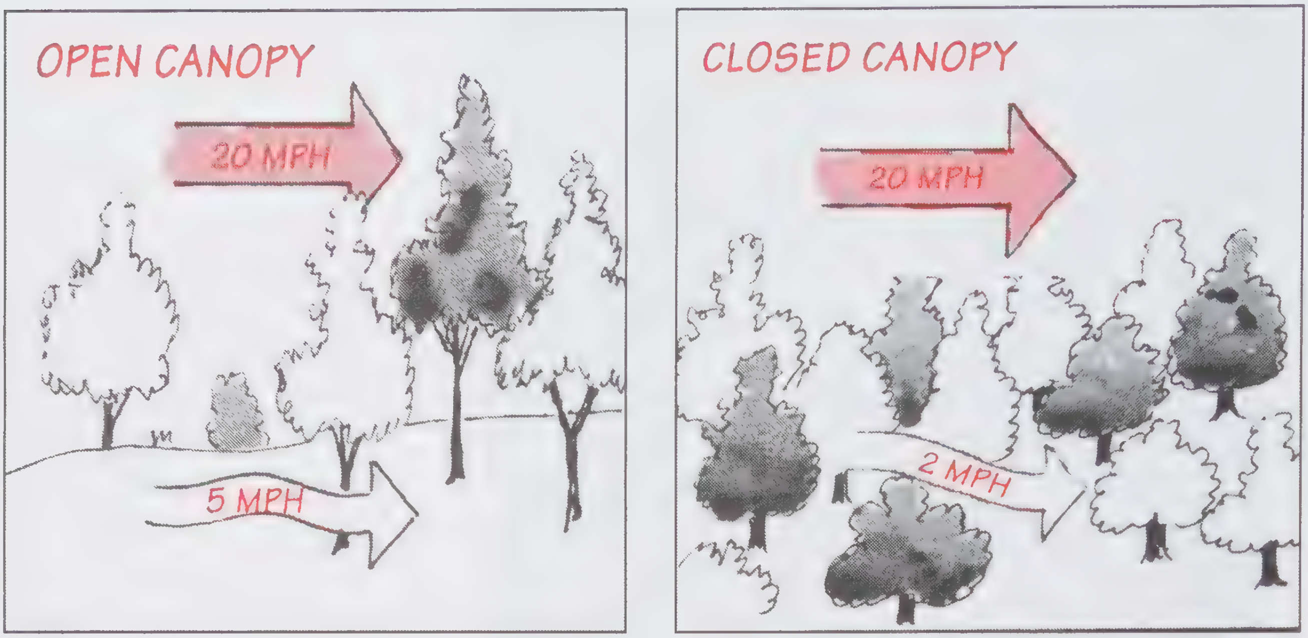


Figure 3.29 A closed canopy reduces the amount of wind, holds in moisture, and reduces the solar radiation that reaches the surface.

Fuel moisture affects all of the fire behavior characteristics.

greater the amount of dead fuel compared to live fuel, the more flammable the total fuel load (Figure 3.33). The forest fuels with higher levels of dead-to-live ratios are:

- Older mature stands of brush and timber.
- Fire damaged fuels.
- Fuels impacted by drought or under seasonal stress.
- Fuels infested with insects and/or disease.
- Fuels damaged by wind or snow.

The amount of dead material in the fuel bed is very important since it is the primary source of the heat that will carry fire into the live fuels. If there is little or no dead material present, the live fuels normally will not burn, even under the worst of conditions. Conversely, if there is a high percentage of dead material present, a live stand will burn even under modest burning conditions. You should take note of the level of dead material, and have some idea of the fuel moisture that is present. **Fuel moisture is the one fuel characteristic that affects all of the fire behavior characteristics.**

The gases released from pitch, sap, oils, resins, and waxes found in woody material also burn. The combustion of these chemical compounds and the gases they release can be demonstrated by placing some forest litter in a covered can and heating

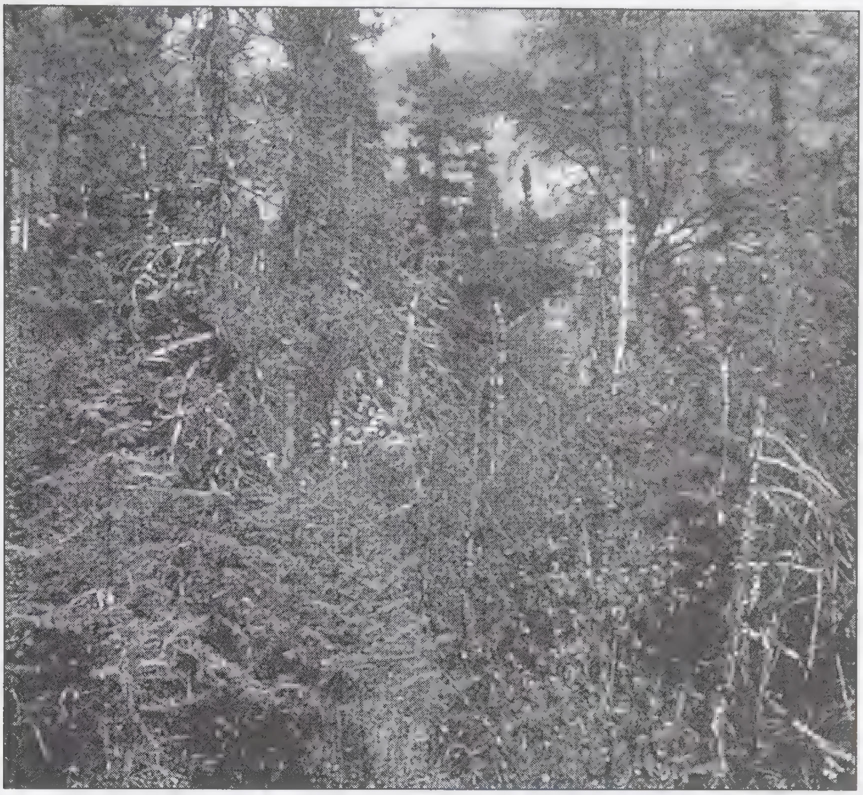


Figure 3.30 When the vertical arrangement of fuels is continuous, it is said that there are ladder fuels, fuels that can allow fire to move into the crowns of the trees with ease.

The higher the "oil content" of the fuels, the hotter they will burn.

The moisture in dead fuels is primarily changed by moisture in the air.

it. If a small hole is opened in the top of the can, the gases released by the heated fuel will burn (Figure 3.34). The concern you should have as a fire officer is that the very high level of chemicals in some wildland fuels can greatly intensify your fire. This may influence your control strategy.

Some of the more volatile fuels that can burn with high intensity and fire spread are chaparral in the Southwest (Figure 3.35), palmetto in the Southeast (Figure 3.36), and greasewood in the Great Basin

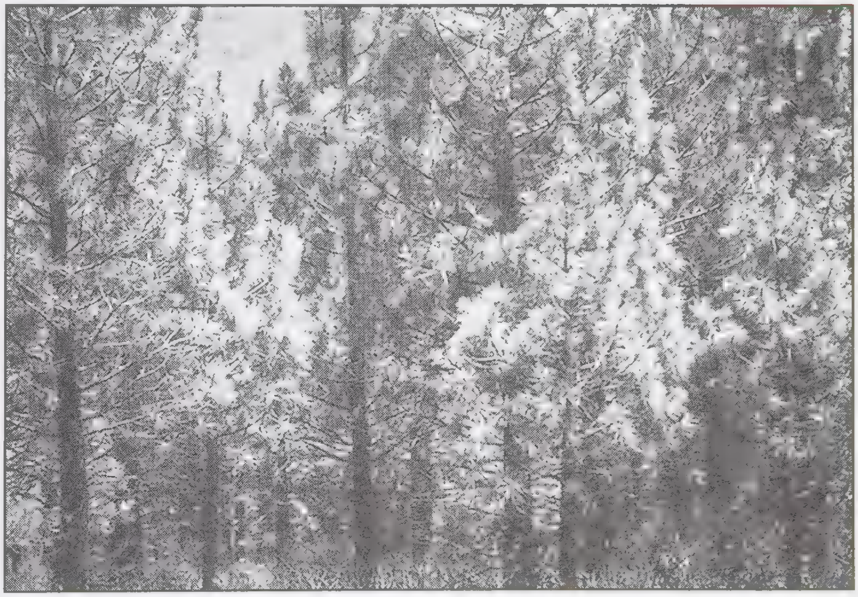


Figure 3.31 A low intensity fire has moved through this area, consuming the surface fuels, but not the aerial fuels. Note how the surface fire has dried out the tops of these trees. A reburn in this area is possible under the right conditions.

The finer the fuel, the quicker the fuel moisture can change.

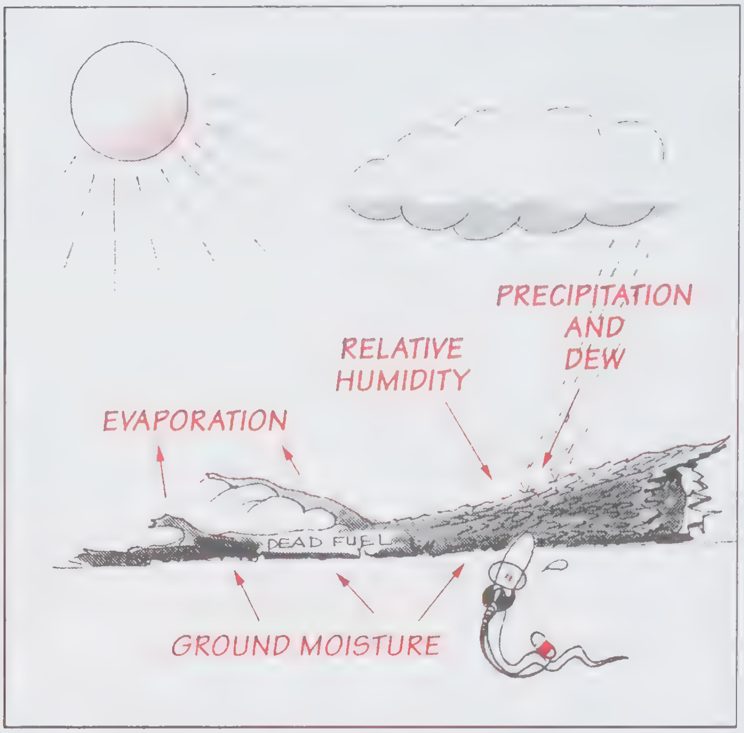

PRECIPITATION AND DEW
RELATIVE HUMIDITY
EVAPORATION
DEAD FUEL
GROUND MOISTURE

Figure 3.32 Fuels take on or lose moisture in several ways.

The higher the percentage of dead fuel to live fuel, the more flammable the total fuel load.

Figure 3.33 The more dead fuel in a fuel bed, the more flammable the total fuel load will be.

(Figure 3.37). All of these fuels emit very dark to black smoke. This is caused by the high level of volatile oils they contain.

Dead fuel moisture is the moisture content in dead fuels. Dead fuel moisture is primarily changed by the moisture content of the air. **Dead fuel timelag** is the time it takes for the moisture content of dead fuels and the surrounding air to equalize. Timelag is expressed as a rate in hours. Grass is considered a 1-hour fuel. It takes about 1 hour of exposure to significantly increase or decrease the moisture content in dead grass. Figure 3.38 describes the four dead fuel timelag categories.

Available fuels are those fuels that will ignite and support combustion under specific conditions. Normally, only a portion of the fuels in an area are available to burn. How much will burn is primarily controlled by the size of the material and its moisture content. As a general rule, the drier the material, the more of it will be consumed. The larger the material, the less of it will be consumed.

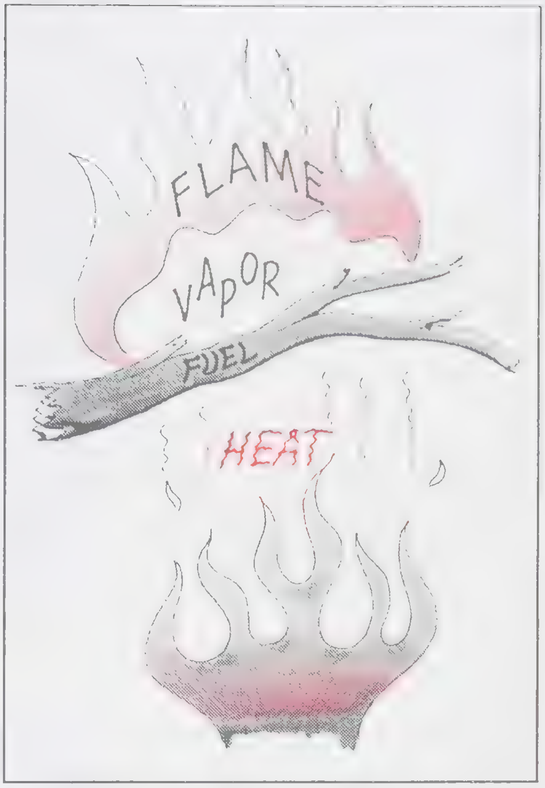
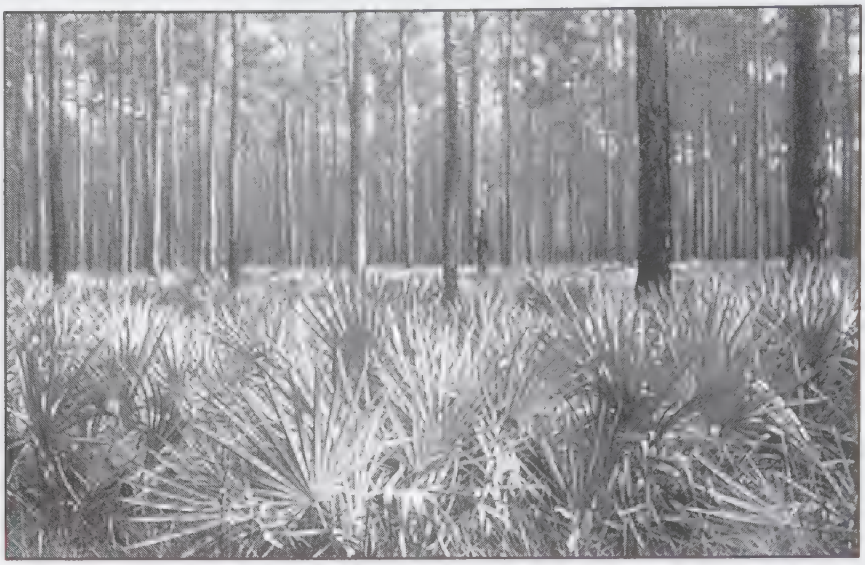


Figure 3.34 The volatile gases released by heating the fuels are what really burn. Some fuels have higher chemical levels than others. You should be able to recognize such fuels.

Figure 3.35 Chaparral, found throughout the Pacific Southwest, is extremely volatile and dangerous. It can burn with very high intensity and a rapid rate of spread.

The gases released by heating are what really burn!



Some of the most volatile fuels are chaparral, palmetto and greasewood.

Figure 3.36 Palmetto is found in the Southeast. It has a very innocent look to it, but can burn with considerable intensity.

Figure 3.37 Greasewood is just a weed, but has a high level of oil content.

Grass is a fine fuel and can quickly attain very low fuel moistures.

In cured grass, the consumption will be just about total, or 100 percent. Grass is a fine fuel and can attain very low fuel moistures. You will normally not see total consumption in brush or shrub fuels. It may range from 5 to 95 percent (Figure 3.39). In a timber stand, you may find the litter is totally consumed, with some of the trees partially consumed. The overall consumption

Dead fuel moisture...time lag relationship to fuel size

Time lag	Diameter of fuel	Examples
1 hour	less than 1/4"	Annual grass
10 hours	1/4" - 1"	Coastal sage, juniper, and chaparral
100 hours	1" - 3"	Logging slash
1,000 hours	3" - 8"	Logs and mature standing timber

Figure 3.38 The relationship between dead fuel moisture, the size of the fuel, and the associated timelag for the fuel to reach equilibrium with atmospheric moisture.

The time it takes for fuel moisture to change is tied to the size of the fuel.

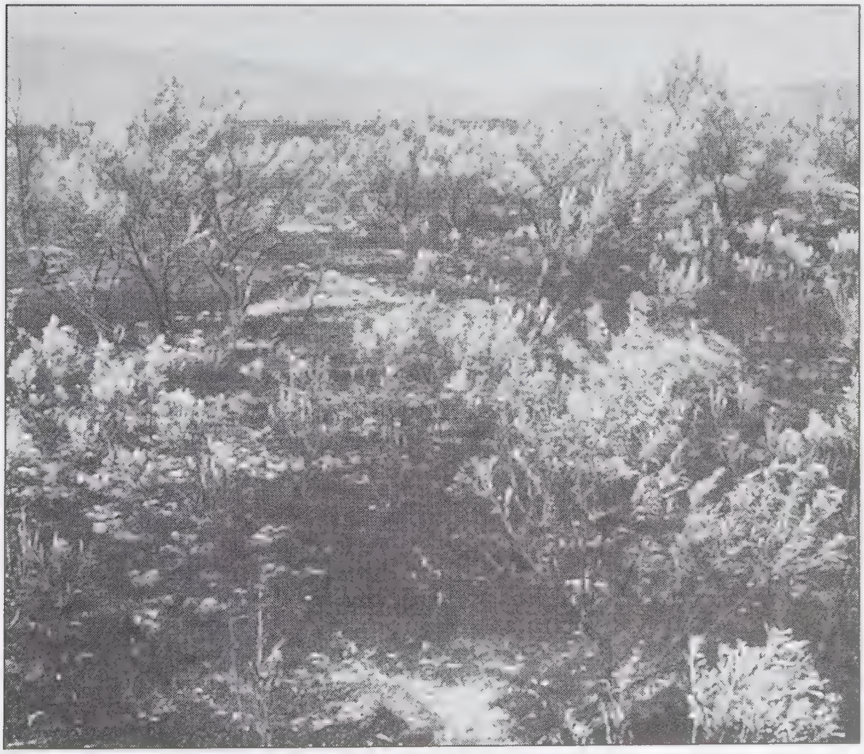


Figure 3.39 Most of this grass/shrub fuel has been consumed.

The amount of the fuel actually consumed is primarily controlled by the fuel moisture.

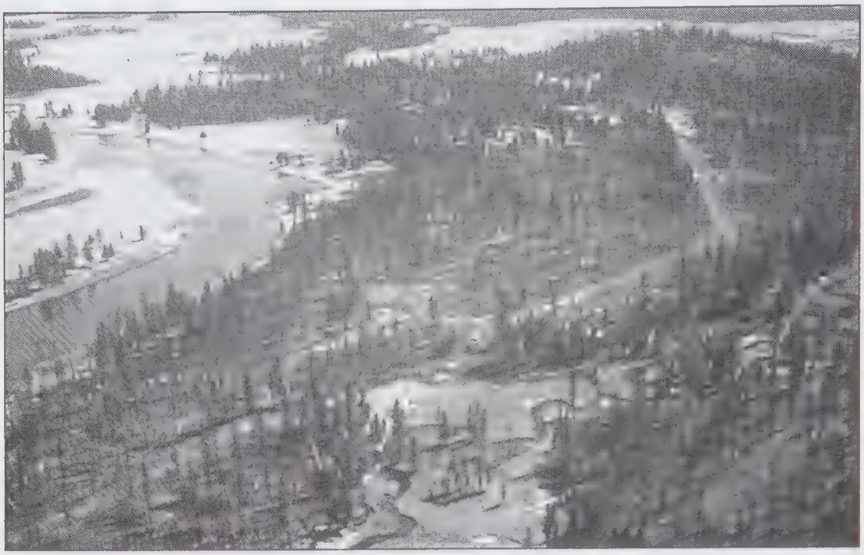


Figure 3.40 This timber fire burned very hotly, but a high percentage of the total fuel loading was not consumed.

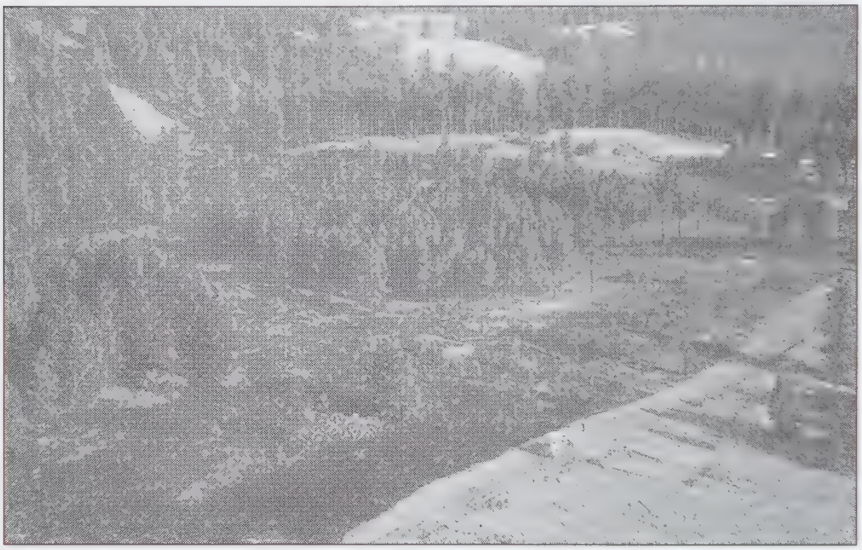


Figure 3.41 In this fire, the grass and light fuels were consumed, but the timber was virtually untouched. There was insufficient heat generated by the surface fuels to carry the fire into the crowns of the timber.

The closer the heavy fuels are together, the faster they will burn.

may range from 5 to 25 percent (Figures 3.40 and 3.41). Stumps, logs, and the larger limbs in logging slash are rarely totally consumed. Normally you can expect 10 to 70 percent consumption (Figure 3.42).

This variability in consumption is controlled by fuel moisture and the overall mass of the fuel. Larger fuels generally have a higher fuel moisture content, and because of their mass, take considerably more heat to ignite and support combustion. The general arrangement of the fuels is also critical. The farther apart the heavy fuels are spaced, the more quickly they will cool and combustion will stop. In fact, to separate the larger materials is one method that is used to mop-up a fire in heavy fuels.

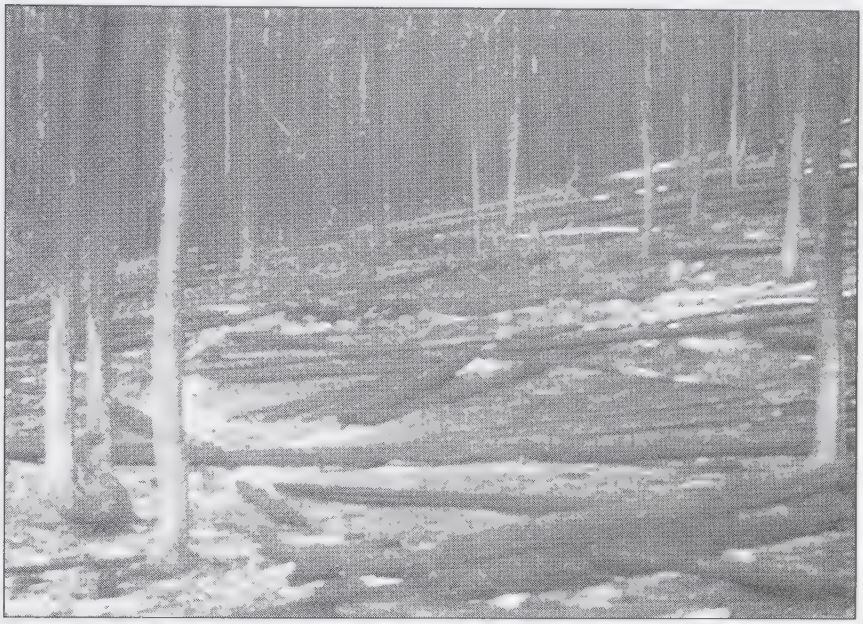


Figure 3.42 Most of the 1000-hour fuels in this lodgepole pine stand were consumed, yet the larger material remains.

Fuel Moisture

As has been stressed previously, the moisture content in fuels is one of the most important factors in both ease of ignition and how a particular fuel will burn. Most "fuel beds" contain both live and dead fuels, so there may be considerable differences in fuel moisture content (Figure 3.43). This difference in fuel moisture content "controls" what fuels will actually be burning in the flame front. Weather conditions control the availability of moisture in the form of precipitation or water vapor in the air, while aspect influences the level of solar radiation.

Fuel moisture content is most important; it controls the ease of ignition and intensity of the fire.

Once again, fuel moisture content is defined as the amount of water in a fuel, and is expressed as a percent of dry weight of that fuel. The most precise way to determine the moisture content of a fuel is to weigh a sample of fuel, dry it in an oven, then

Figure 3.43 Fuel moisture "controls" what fuels will actually burn and with what intensity.

weigh it again. The difference between the two weights is the weight of the water. A fuel with no moisture in it has a 0% water content. If the weight of a dry fuel and the water that was in it are equal, it has a fuel moisture content of 100%. It is normal for live fuel to have a moisture content above 100%.

Each area and fuel type have a "window" in which they will burn.

There are many variables in the types of fuels you will be required to deal with. You may be called upon to fight fire in the desert where the fuels are sparse, or in areas in the West where the slash may be 20 feet deep and the trees 300 feet tall. The fuels may also from one site to another in a particular area. Some brush fields or timber may cover hundreds of thousands of acres, or the area may have grass on the ridges and patches of timber in the draws. This variability is the reason you must assess the fuel moisture content of both the fuels that are burning and those that are available to burn.

Each fuel type and area have "weather windows" during which time they are most likely to burn. The fuels in desert areas are dry during most of the summer, but will not usually burn with high intensity unless driven by a wind. The brush fields of Southern California may burn with fairly high intensity most of the summer. The grasslands of the Midwest will burn during the spring before "green up," and the conifer forests of the Pacific Northwest will burn with high intensity when there is a drought.

The fuel moisture will vary in light fuels by the hour, and in the larger fuels from day-to-day. When fuels are hot and dry, they ignite and burn with relative ease. When fuels are cool and wet, the possibility of ignition will be reduced; if ignited, the fuels will burn very poorly (Figure 3.44). During a normal fire season, the fuel moisture you encounter can be anywhere between the two extremes, very wet to very dry.

The temperature of the fuel affects ignition. Temperature also affects fuel moisture.

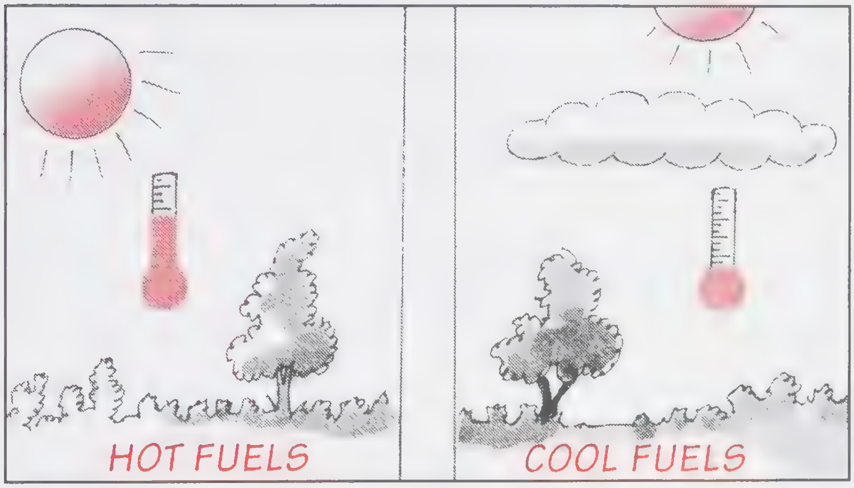


Figure 3.44 When fuels are hot and fuel moistures are low, fires will start and burn with some intensity. When fuels are cool and moist, they will usually not ignite, or if they do, they will burn poorly.

Grass is an herbaceous plant.

Living Fuels

There are two categories of living fuels: herbaceous and woody. Herbaceous plants are those that do not have woody material, like annual grasses or perennial plants. The woody plant material that you should be most concerned with are the twigs, leaves, needles, and small limbs that will be consumed by the flame front of a fire.

Woody plants have twigs, leaves and needles.

Plants that "shed" their leaves each fall are called deciduous. The shed leaves are dead and constitute fine fuels. Evergreen plants are those that do not annually "shed" all of their leaves or needles, but they do "shed" some of them. The new growth has high fuel moistures, whereas the older foliage will have a much lower moisture content (Figure 3.45).

The fuel moisture content of woody vegetation foliage is found in new growth, shoots and stems. The level of fuel moisture content in these fuels usually decreases as the growing season progresses. The lowest amounts occur in late summer or early autumn. Moisture content can range from 2% to 30% in dead fuels, and 30% to over 300% in live fuels.

Live fuel moisture changes with the time of year.

Why the difference in fuel moistures between new foliage, older foliage, and dead fuels? Living cells, like those found in new and older foliage, have the capability of holding a lot of water, which they use to produce and transport food, and to cool the plant. Dead cells are much less "elastic," and thus become saturated with moisture at about 30%.

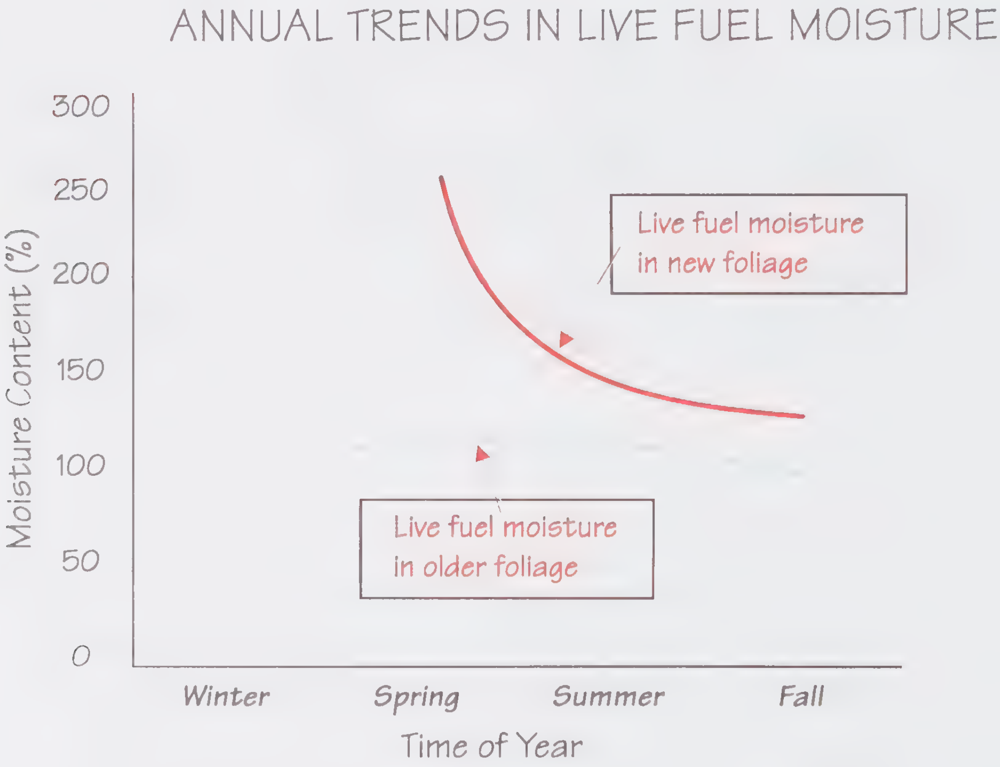


Figure 3.45 The live fuel moisture in an evergreen tree varies from new foliage to old foliage, and by time of year.

Stages of Vegetative Development

There are five distinct stages of growth in vegetation, and each one has a predictable live fuel moisture content. You can use this to help predict fire behavior when you don't have precise fuel moisture data (Figure 3.46).

The fuel moisture can also be impacted by several natural events:

- Long dry periods or a drought.
- Disease, insect infestation, or blight.
- Early curing of fuels because of an early spring/summer.
- Timber harvesting (because remaining trees receive more solar radiation).
- Storm blowdown and ice/snow breakage.

These natural events create more dead fuel, potentially worsening fire behavior and ease of control.

LIVE FUEL MOISTURE CONTENT

Stages of Vegetative Development	Percentage of Fuel Moisture
Fresh new foliage. Growing annual grasses. Early in growing cycle. Very green in color.	300
Mature foliage, but still developing. Cells are still saturated with water.	200
Mature foliage, growth has stopped. Older perennial foliage. May be turning a darker shade of green.	100
Entering dormancy. Coloration starting to change. Some leaves may be dropping from stem.	50
Completely cured. In full fall colors, to brown.	Less than 30. Treat as a dead fuel.

Figure 3.46 The five stages of growth and fuel moisture content.

Grasses

Most wildland fires occur in grasses or light fuels. It may be the sole fuel, or it may serve to carry the fire into brush or timber fuels. Three factors control how "well" the grass will burn: level of curing (grass that is not cured will not burn), amount of fuel (the more the fuel, the hotter and longer the grass will burn), and the dead fuel moisture (grasses with fuel moistures above 30% will not normally burn). Fuel moisture in grasses in the "living stage" are usually above 100%, but will drop to about 30% as it is curing (in the transition stage), and below 30% in the cured stage. Generally, more than $^1/_3$ of the grass has to be dead and dry before grass will carry fire.

Most of the fires you will fight will be in grass.

In the West, we think in terms of a summer fire season. The grasses begin to mature and die in the spring. As the summer turns warm, the grasses turn brown and can easily burn. Burning conditions can change from day-to-day based on the moisture in the air. In the Midwest, or other areas where the summer is usually wet, the grasses burn during two distinct seasons. The first occurs as the snow retreats and the dead grasses dry out. As soon as the soil warms enough to germinate grass seed, the grass will begin to grow or "green up." Once this starts, the number and intensity of grass fires diminishes until the fall when they cure and burn again (Figure 3.47).

In the West, the grass will burn most of the summer months. In the Midwest, where summer rains cause the grass to "green up," the worst grass fires are in the spring or fall months.

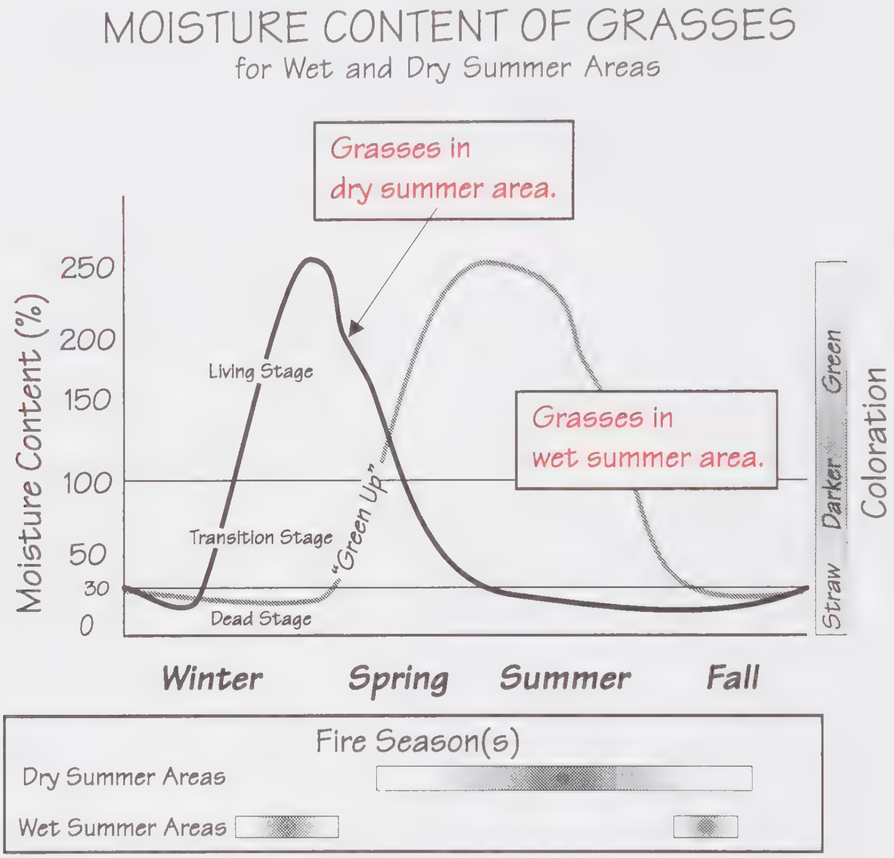


Figure 3.47 Moisture content of grass changes based on the geographic area and time of the year.

The fuel moisture in fine fuels varies from day-to-day.

Fuel Moisture in Dead Fuels

Dead fuels (fallen leaves, needles, twigs, and limbs, and cured grasses) constitute the majority of the fuels that you will have to deal with. The moisture content of the finer fuels varies from day-to-day. The fuel moisture in the larger dead fuels (limbs and logs) will vary by week or month. Moisture in the atmosphere is the primary factor that causes variations in the moisture content of dead fuels (See Figure 3.32, page 130).

The moisture in the atmosphere is constantly changing. It changes from season-to-season, day-to-day, and even from hour-to-hour. The moisture content in the atmosphere is also different from location-to-location over relatively small areas. It is important that you recognize these variations and understand how they affect fire behavior.

Winds increase drying.

The dead fuels and the atmosphere are constantly "exchanging" moisture. If the air is wetter than the fuels, the fuels will take on moisture. If the air is dryer than the fuels, the fuels will give up moisture and begin to dry out. There are several factors that regulate the rate at which this exchange occurs:

- The difference in moisture content of the air and fuel - the greater the difference, the quicker the levels will change.
- The wind - if the wind is blowing, both the movement of air around the fuels and the level of moisture exchange will be greater. Conversely, if the air is calm, the exchange will be much slower.
- The size of the fuels - the smaller the fuel, the quicker the moisture content will change.
- The compactness of the fuels - if the fuels are tightly packed, there will be less air movement around the fuels and thus slower moisture exchange.
- The relationship of the fuels to damp or moist soil - if the fuel is laying on damp or moist soil, a change in atmospheric moisture will have less impact.

Smaller fuels accommodate changes in fuel moisture faster.

In the chapter on fire weather, you learned that the various air masses were always attempting to equalize temperature, pressure, moisture content, etc. This same concept applies to fuel moisture. If the moisture in the air and fuels are the same, it is said that they have reached equilibrium. Equilibrium can only occur in the finer fuels because it takes so long for the moisture content to change in larger fuels.

Dead fuel moisture is influenced by relative humidity, precipitation, temperature and wind.

There are several environmental factors that directly influence dead fuel moisture: relative humidity, precipitation, temperature and wind. Other factors have an indirect influence on fuel moisture: time of day, cloud cover, amount of shade, fuel canopy, aspect, slope, solar radiation, and elevation (Figure 3.48).

The factors that influence fuel moisture vary from site to site. **Shade** is one of those site specific factors which has a direct influence on temperature. Take, for example, a warm summer day with an air temperature of 85°. The surface temperature can vary as much as 50°, from 110° in the shade to 160° in an unshaded area. Meanwhile, the dead fuel moisture can be 8% in the shade and only 3% in unshaded areas. It may not seem like a lot, but that 5% can mean a significant difference in terms of fire behavior.

Shade is a site specific factor.

Another influencing factor is **aspect** or lay of the land. Aspect impacts the angle at which solar radiation strikes the earth. This in turn influences temperature, relative humidity, and fuel moisture (Figure 3.49).

Aspect or lay of the land impacts the angle at which solar radiation strikes the earth.

Southern slopes receive more heating during the afternoon than any other aspect. This means temperatures will be higher, while relative humidity and fuel moisture will be lower. Flat areas receive about the same intense heating as a southern slope. As you can see from Figure 3.49, the fuels on east facing slopes reach

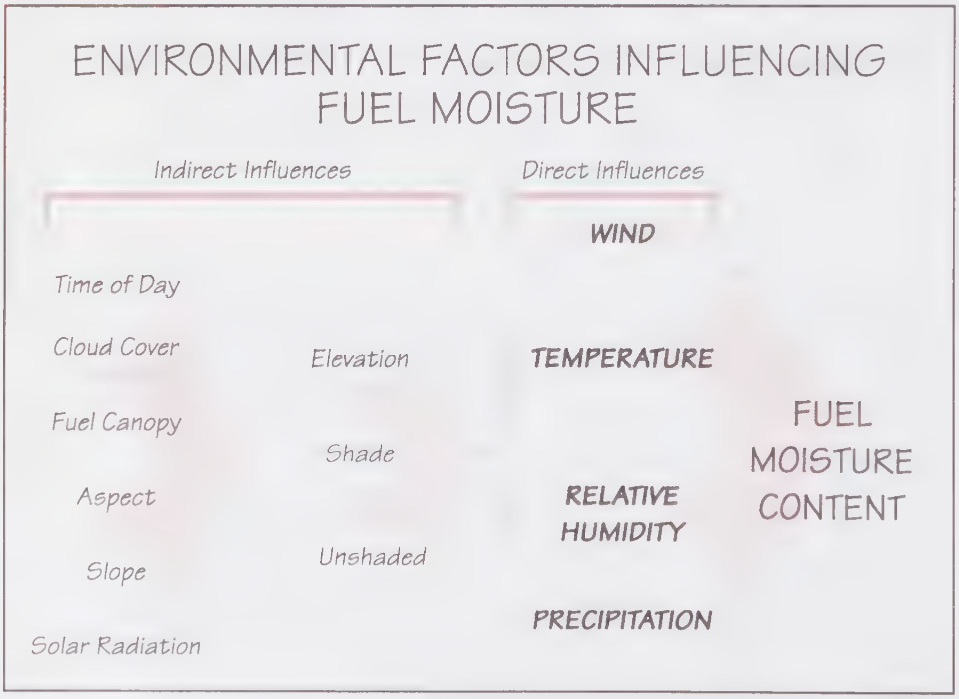
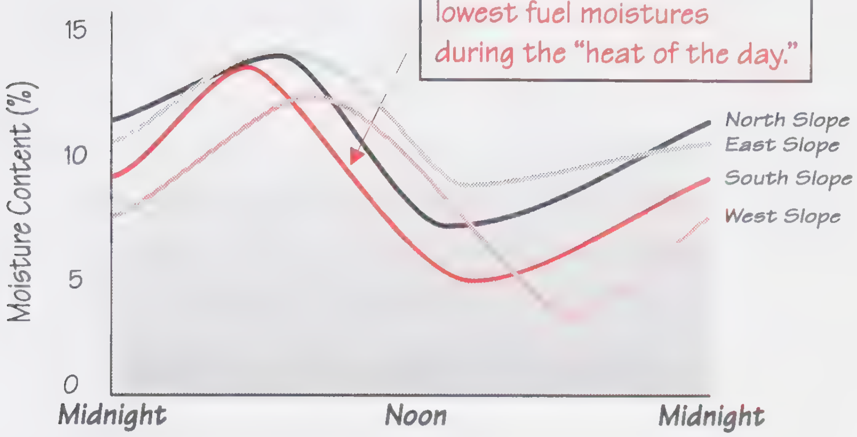

ENVIRONMENTAL FACTORS INFLUENCING FUEL MOISTURE
Indirect Influences
Direct Influences
WIND
Time of Day
Cloud Cover
Elevation
TEMPERATURE
Fuel Canopy
FUEL MOISTURE CONTENT
Shade
Aspect
RELATIVE HUMIDITY
Unshaded
Slope
PRECIPITATION
Solar Radiation

Figure 3.48 Environmental factors that influence fuel moisture.

INFLUENCE OF ASPECT ON FUEL MOISTURE

South slope has the lowest fuel moistures during the "heat of the day."



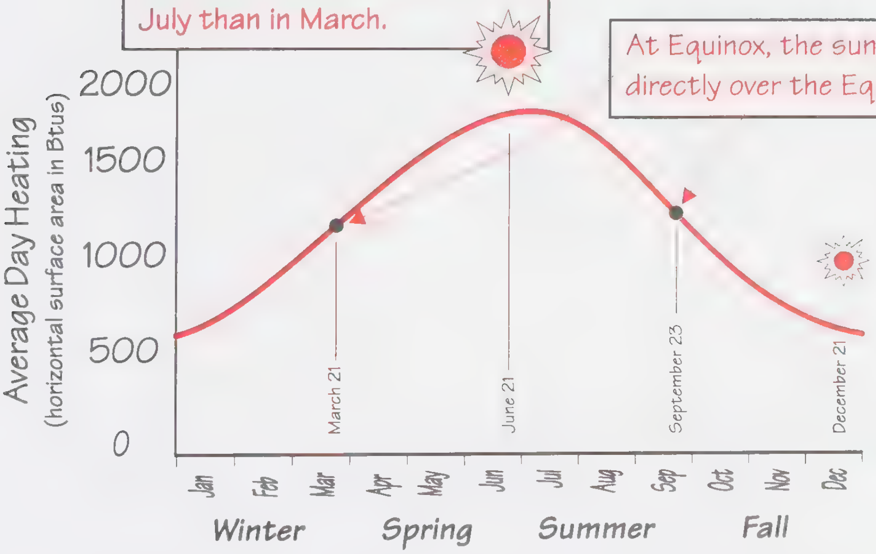
Time of the year also influences fuel moisture.

Figure 3.49 Aspect has an influence on fuel moisture.

SOLAR HEATING OF THE EARTH

An area may receive twice as much solar radiation during July than in March.

At Equinox, the sun is directly over the Equator.



Solar heating is the highest on June 21, when the sun is at its peak angle in the northern hemisphere.

Figure 3.50 The amount of solar heating varies by time of the year. This is the result of the sun being at different angles in relationship to the earth. The sun is at its peak on June 21 (the first day of summer), and at its lowest point in the southern skies on December 21 (the first day of winter).

their lowest fuel moisture contents by early afternoon; south and west slopes have the lowest fuel moistures during the heat of the day. South and southwest aspects have the lowest average fuel moisture contents.

The **time of year** indirectly influences fuel moisture in that at different times of the year, the sun is at different angles in relation to the earth's surface. During the winter, the sun is low in the southern skies as it moves from east to west. On June 21, it is at its peak. Figure 3.50 shows how the change in angle changes the heating of the earth. The actual amount of solar radiation that reaches the earth varies with the amount of average cloud cover and the distance you are from the Equator. The further north you are, the less solar radiation you will receive.

Elevation affects fuel moisture.

Another influence on fuel moisture is **elevation**. Remember the lapse rate. Temperature changes about 3½° for each 1,000 foot change in elevation. If temperature changes within an air mass, there is a corresponding change in relative humidity and fuel moisture (Figure 3.51).

Slope, also, has an influence on fuel moisture. The closer the slope is to perpendicular, the greater the amount of solar radiation

INFLUENCE OF ELEVATION ON FUEL MOISTURE

	Elevation	Temperature	Relative Humidity	Fuel Moisture
Change in Elevation	6,000	69°	39%	8%
	5,000	73°	35%	7%
	4,000	76°	31%	6%
	3,000	80°	27%	5%
	2,000	83°	25%	5%
	1,000	87°	22%	4%

Figure 3.51 Elevation can also impact fuel moisture. As you rise in elevation, the air cools at about 3½° per 1,000 feet. This changes the relative humidity and fuel moisture.

Foehn winds can dry out fuels very quickly.

(Figure 3.52). The higher the level of radiation, the higher the temperature and the lower the fuel moisture.

Wind influences fuel moisture in several ways. It can increase the rate of evaporation by moving moist, damp air located near the fuels, and replacing it with drier air, which dries the fuels. If the wind is one of the Foehn (drying) winds, it can dry the fuels very quickly. However, if the wind is strong enough, it will actually cool the fuels and slow the drying process.

The maximum radiation is received when the sun and the earth's surface are at 90° to each other.

Precipitation is a factor in fuel moisture. Three main factors influence the level of impact: the amount of rain, the duration of the rain, and the size of the fuels (Figure 3.53). As noted previously, the finer fuels will "take on" moisture much faster than the larger fuels. The opposite occurs when the skies clear.

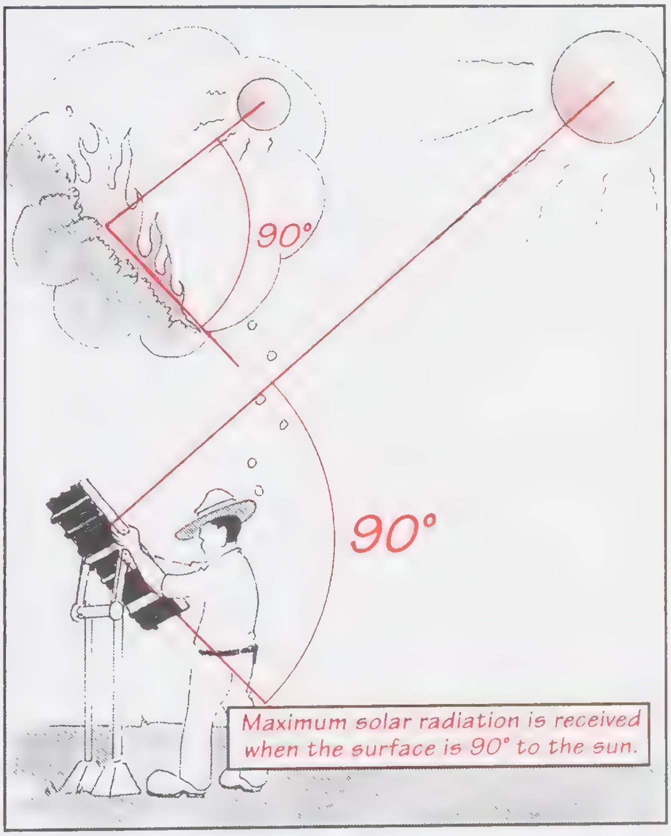

90°
90°
Maximum solar radiation is received when the surface is 90° to the sun.

Figure 3.52 The amount of solar radiation striking the earth is influenced by the angle of the slope in relation to the angle of the sun. The closer it is to 90°, the greater the level of radiation, thus the higher the temperature and the lower the relative humidity and fuel moisture.

The larger the fuel, the longer it takes to change its fuel moisture.

Figure 3.53 shows the average level of influence on the three fuel size classes. Note how quickly the lighter fuels reach their maximum fuel moisture capacity, as compared to the 100-hour fuels which only reach about 20% fuel moisture after 16 hours of continuous rain.

Dead fuel cells cannot "take on" over 30% moisture.

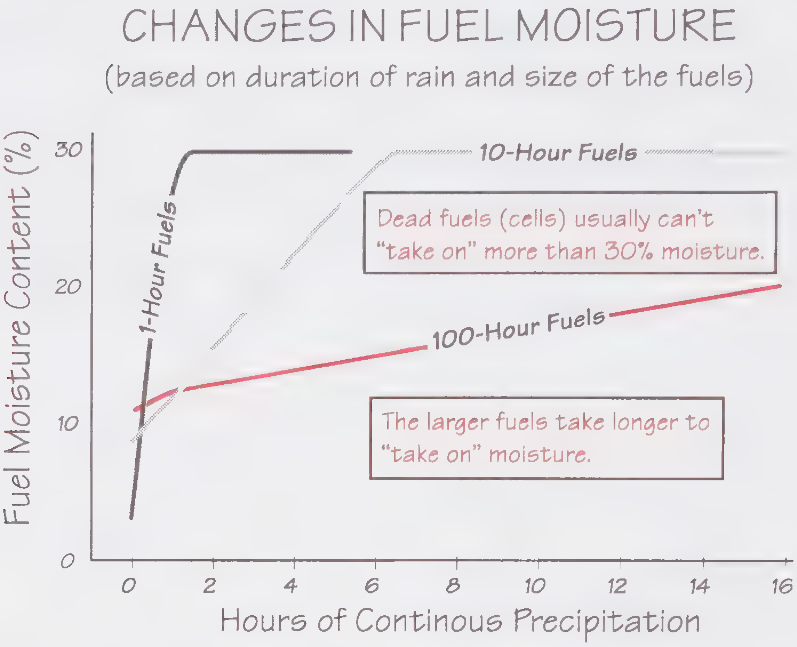


Figure 3.53 Rain will change fuel moisture. Three factors influence how: the amount of rain, the duration of the rain, and the size of the fuels involved.

Fuel Moisture Timelag

Fuel moisture timelag is defined as the time it takes a fuel of a certain size to gain (or lose) moisture when the environment around it changes. This rate of change is not constant. The first introduction of moisture or drying brings on a quick response, but the response rate slows over time.

The larger the fuel, the less the surface area-to-volume ratio, thus the longer the timelag. Figure 3.54 charts the relationship between the diameter of fuel and its fuel moisture timelag. This chart shows that a 3" piece of limb wood has a fuel moisture timelag of about 7 days.

Different size fuels react to changes in moisture content at different rates. Figure 3.55 shows the rise and fall of moisture content in two fuels: a 12" log (a 1,000-hour timelag fuel), and a ½-inch stick (a 1-hour timelag fuel). You can see that the ½-inch stick increases its fuel moisture at a much faster rate than the 12" log. But, the 12" log lags in recovery after the rain has stopped. This is because they have different timelag rates. Review the definition of the four timelag categories (Figure 3.38, page 133).

Since the fuel grouping that is most vulnerable to ignition and fire spread is the fine or 1-hour fuels, this is the fuel moisture that you should track as often as possible. Since this fuel is also the one that is most reactive to changes in relative humidity, you can track the status of the fine dead fuels by tracking changes in relative humidity (Figure 3.56).

Unless there is a significant change in the air mass in the area, relative humidity usually rises during the night as the temperature lowers. This causes the highest relative humidity readings to occur about sunrise. Then, as solar radiation begins to warm the surface, and the air above it begins to warm as well, there will be a corresponding drop in both the relative humidity and the fuel moisture content. The fine fuel moisture will lag behind the change in relative humidity. Fine fuels lying close to the ground will take a little longer to change moisture content than standing fuels, because of lower air circulation and direct contact with the moist soil.

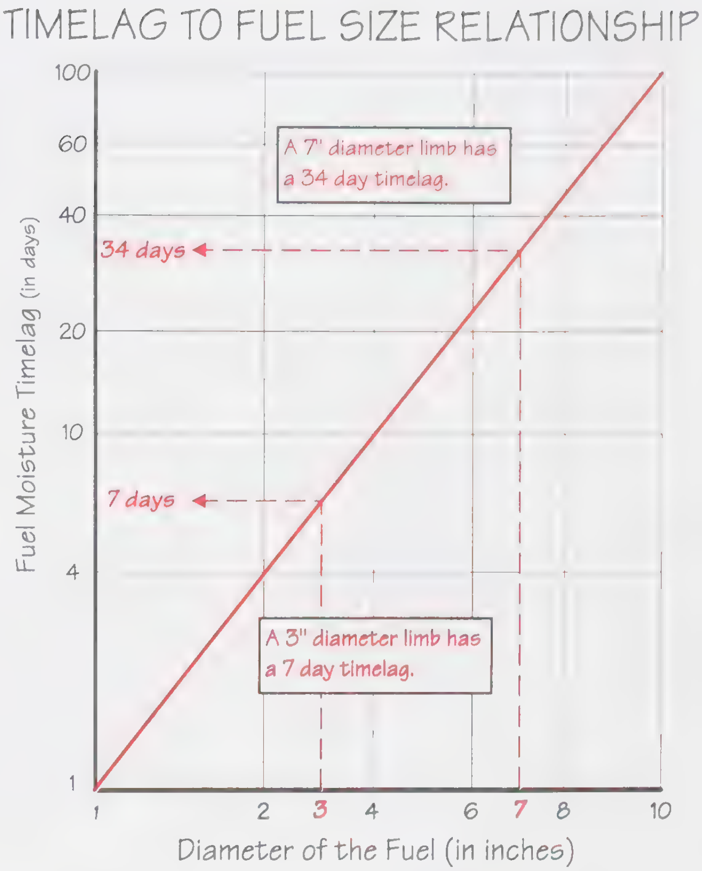
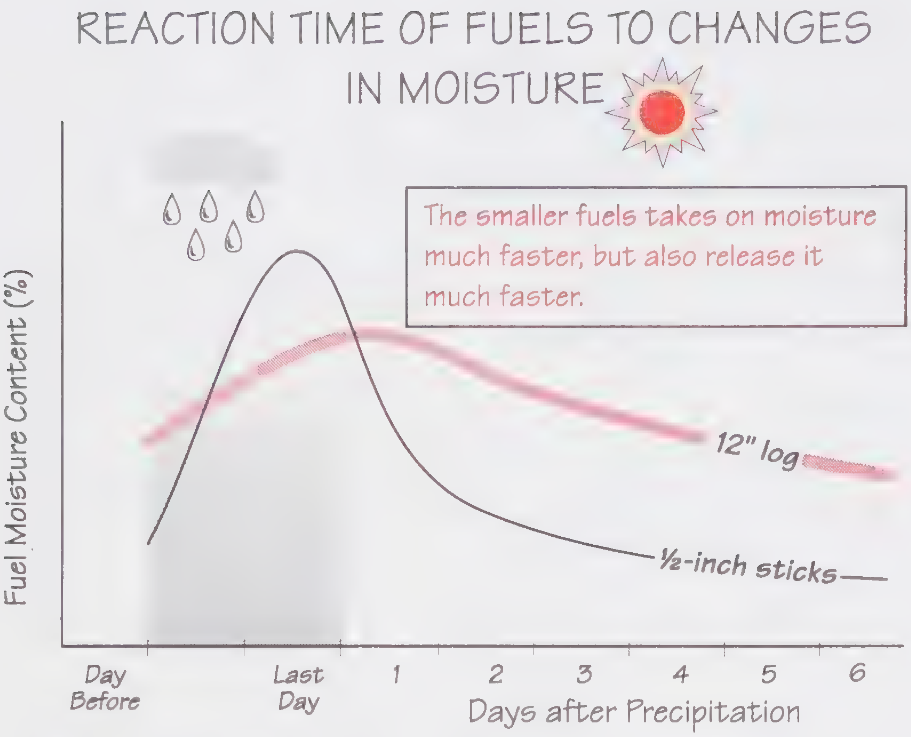


Figure 3.54 There is a relationship between the diameter of a fuel and its fuel moisture timelag.

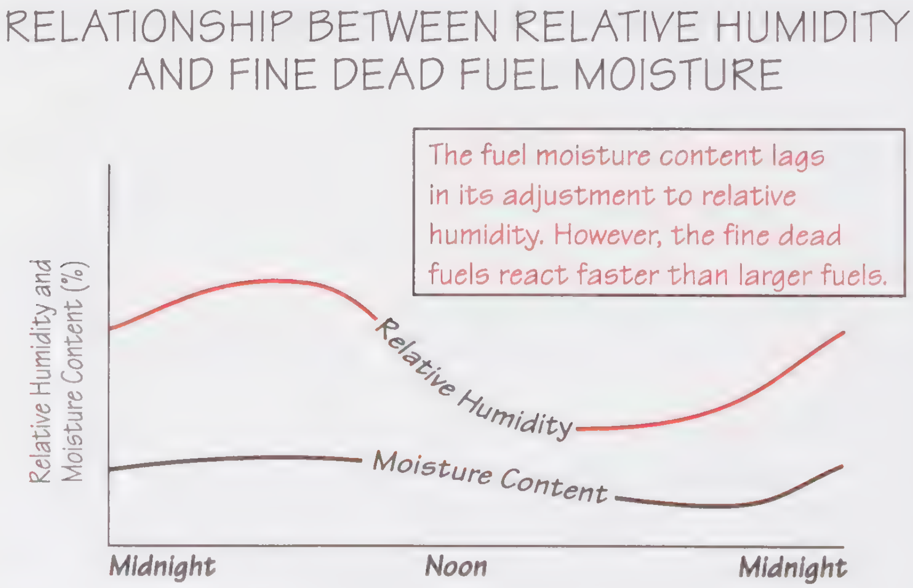
You should calculate the fine fuel moisture frequently.



The smaller fuels takes on moisture much faster, but also release it much faster.

Figure 3.55 Different fuels react at different rates when they are different sizes. Smaller fuels react more quickly than larger fuels.

Changes in fuel moisture content lag behind changes in relative humidity.



The fuel moisture content lags in its adjustment to relative humidity. However, the fine dead fuels react faster than larger fuels.

Figure 3.56 Knowing the relationship between relative humidity and fine dead fuel moisture can be very helpful. By tracking changes in relative humidity, you can track the status of fine dead fuel moisture.

4

Fire Behavior

> ***"....In the days preceeding the incident, the weather had been hot and dry. On the day of the incident, temperatures were near 100°, relative humidity was approximately 15%, the Haines Index was 6....The fire was moving rapidly and burning intensely. Flame lengths were at least 20 feet long, and the rate-of-spread was estimated to be about 560 feet per minute. It took four minutes, from the point of escape, for the fire to overrun the truck."*** *Point fire Accident Investgation, Bureau of Land Management, June 28, 1995.*

To be successful as a wildland fire officer, you need to understand and be able to predict what the fire is going to do under various conditions. Reading this chapter will not make you a fire behavior analyst, but it should give you important information that will assist you in developing appropriate suppression strategies and tactics for varying conditions. The key to success is to automatically recognize the factors, present and predicted, that will affect how you should fight a fire. The main goal for this chapter is that you develop an appreciation and understanding for what is happening around you, and what will be happening around you as the fire progresses.

Before getting into fire prediction, we'll discuss how the various factors that control fire behavior come together and interact. This is called the fire environment.

In this chapter, you'll

- *Learn how various factors that make-up the fire environment affect fire behavior.*
- *Learn to identify the factors that influence a fire's rate of spread.*
- *Understand the 3-dimensional aspects of a wildland fire.*
- *Learn how the various fire behavior characteristics will help "set" your strategies and tactics.*
- *Gain an understanding of the differences between the different fire behavior fuel models.*
- *Learn to use fire behavior nomograms.*
- *Learn to estimate acreage and length of perimeter based on predicted rate of spread.*

Fire Environment

The fire environment includes all of the factors that allow a fire to start, burn, and spread. There are sixteen primary factors that influence how a wildland fire will burn (Figure 4.1). The fire's rate of spread, intensity, and other characteristics respond to these. Some of these factors can, in turn, be influenced by the fire

WILDLAND FIRE ENVIRONMENT

The fire environment controls the level of fire behavior.

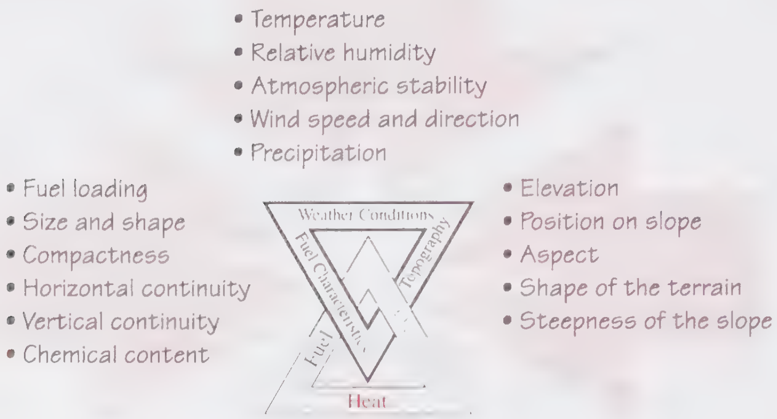

• Temperature
• Relative humidity
• Atmospheric stability
• Wind speed and direction
• Precipitation
• Fuel loading
• Size and shape
• Compactness
• Horizontal continuity
• Vertical continuity
• Chemical content
• Elevation
• Position on slope
• Aspect
• Shape of the terrain
• Steepness of the slope
Weather Conditions
Topography
Fuel Characteristics
Fuel
Heat

Figure 4.1 The wildland fire environment influences the behavior of a fire. All of the factors interact with each other to set fire behavior at a specific point in time. As the factors change, the fire behavior also changes. For instance, as time passes, so does the position of the sun in relationship to the terrain; and its influence on fuels and air masses.

itself. This process is constantly evolving and changing. Always expect conditions to change on a wildland fire (Figure 4.2).

The weather factors are temperature, relative humidity, stability, wind, and precipitation.

The weather related factors that influence fire behavior are:

- Temperature
- Relative humidity
- Atmospheric stability
- Wind speed and direction
- Precipitation

The most important weather components are wind, temperature, and relative humidity.

Weather is the most variable component of the fire environment. Weather varies as air masses move through an area. It also varies by the time of day. **The most important weather components are wind, temperature, and relative humidity.**

The topographic factors that contribute to fire behavior are:

- Elevation
- Position on the slope
- Aspect and shape of the terrain
- Steepness of slope

These factors are much more constant, but change as the fire moves through an area (up and over hills, from one aspect to another, etc.). **The most important topographic components are steepness of slope and aspect.**

The fuel components are:

- Fuel loading
- Size and shape of the fuel
- Compactness
- Horizontal and vertical continuity
- Chemical content
- Fuel moisture
- Fuel temperature

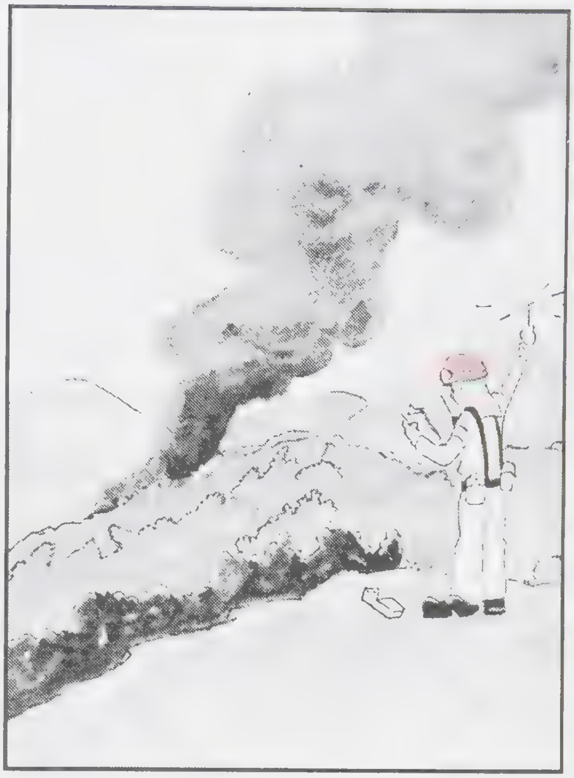


Figure 4.2 As a fire officer, you must constantly check the weather and other conditions that will influence the fire behavior.

These components change as the fire moves through the area (changes in fuel types from grass to brush to timber) and some change when several of the weather factors change. **The most important fuel components are fuel moisture and temperature.**

Each of these components vary with time of day. It is critical that you recognize that changes will be occurring and that you realize what the effect of those changes will be. Some of these changes are very predictable; others are very subtle (Figure 4.3). Figure 4.4 shows how a simple rise in the temperature affects several other factors associated with fire behavior.

The most important topographic factors are slope and aspect.

Physics of Heat Transfer

The physics of heat transfer involves three methods: convection, radiation, and conduction (Figure 4.5). All three of these methods can contribute to the spread of a wildland fire.

Convection is best described as the movement of hot air by the heating of air molecules. As these superheated air molecules come in contact with an object, they transfer heat to it. This heat transfer occurs on all surfaces of the object. A common example of this is a convection oven. Because the heated air completely

The most important fuel components are fuel moisture and temperature.

EFFECTS OF TIME AND SPACE

	Time	Space	Effect
Weather • Temperature • Relative humidity • Atmospheric stability • Wind speed and direction • Precipitation	The weather factors change constantly. This will affect fuel moisture and curing.	Significant changes occur with topography and weather patterns.	Causes a change in rate of spread, direction of spread and fire intensity.
Topography • Fuel loading • Size and shape • Compactness • Horizontal continuity • Vertical continuity • Chemical content	Consider these factors constant.	Changes will occur especially in hilly and mountainous terrain.	Changes the direction and rate of spread.
Fuels • Elevation • Position on slope • Aspect • Shape of the terrain • Steepness of the slope	Fuel moisture of dead and live fuels will change. Changes can be caused by insects, logging, fires, and severe weather.	Weather and topography will alter the fuel type.	Fire intensity will increase as more fuel becomes available to burn.

Figure 4.3 Some fire behavior factors change with time and others are "fixed."

Weather factors are constantly changing: this is why it is so important to track them frequently.

surrounds the food, the convection oven is able to cook food faster than a conventional oven.

Convective heating plays the biggest role in the spread of a wildland fire. The rising heat and smoke column provide the source of hot air. It can spread the fire in several ways. It can carry burning materials to other locations, where they may start spot fires. It can preheat the fuels ahead of the flame front. Although heated air normally rises away from ground fuels, weather and topography can bring the two closer together. A strong wind can push the heated air closer to the fuels, or a slope can bring the fuel closer to the heated air. That is why fires move with the wind or up a hill. Convective heat can also move fire into the crowns of the trees.

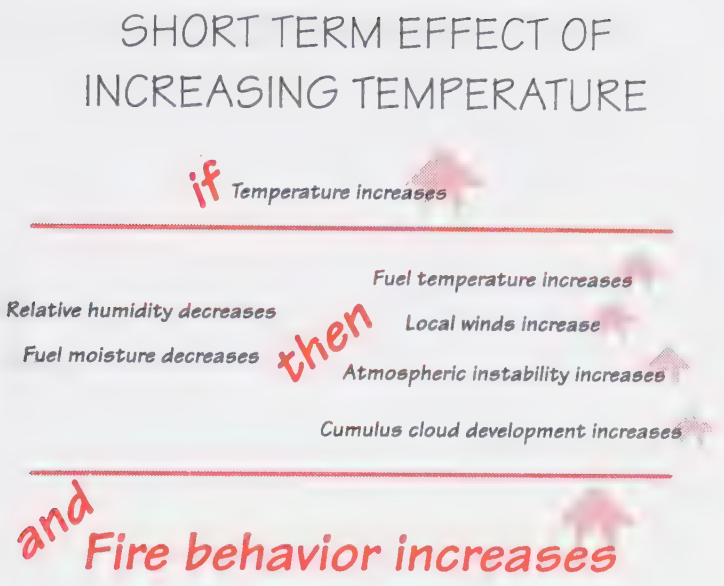

SHORT TERM EFFECT OF INCREASING TEMPERATURE
if
Temperature increases
Relative humidity decreases
Fuel moisture decreases
then
Fuel temperature increases
Local winds increase
Atmospheric instability increases
Cumulus cloud development increases
and
Fire behavior increases

Figure 4.4 If the temperature increases, relative humidity and fuel moisture decrease. When the temperature increases, the fuel temperature, local winds, instability and cloud development will increase. Fire behavior will also increase.

If the temperature increases, relative humidity and fuel moisture drop. When this happens, the level of fire behavior will increase.

The amount of heat transferred to the fuels ahead of the flame front depends on the intensity of the fire and the distance between the heat source and the fuels. Heat transfer is increased when fuels are upslope from the fire; wind is fanning the fire, delivering more oxygen and bending the flame towards the fuel; or fuels are close together, increasing the radiated and conductive heat.

Radiation is the movement of heat energy from the heat source in the form of "waves." These waves travel in a straight line, passing through the air with no effect. They have to strike an object in order to heat it. The best example of radiation is the warming effect of a campfire when you stand back some distance from it. Radiation can also preheat fuels or ignite unburned fuels across firelines. Do not underestimate the importance of radiation in the spread of a wildland fire.

Never underestimate the impact radiated heat energy will have on your fire.

Conduction is best described as the transfer of heat through matter by the movement of energy. This heat transfer happens within the material, molecule by molecule. The transfer rate is directly related to the composition of the object. Copper pipe will transfer heat quite effectively. However, since wood and other

Conductive heat transfer is not as important on a wildland fire.

fuels typically found in a wildland area are poor conductors of heat, conduction does not play a major role in the spread of a wildland fire. Nonetheless, it can cause the fire to "sneak" under the fireline in a burning tree root.

The ability to transfer heat by all three methods depends on the distance from the heat source. The farther an object is from the heat source, the less energy that is transferred (Figure 4.6). Also, if there is a barrier between an object and the heat source, there will be a reduction in heat transfer. To demonstrate the effects of a barrier on radiated heat, hold your hand or a thin piece of paper between the heat source and your face. Note how even the thin piece of paper virtually stops the radiated heat from reaching you. The paper is absorbing the heat instead. Hold that same piece of paper over a column of convective heat and it will probably ignite relatively quickly (Figure 4.7).

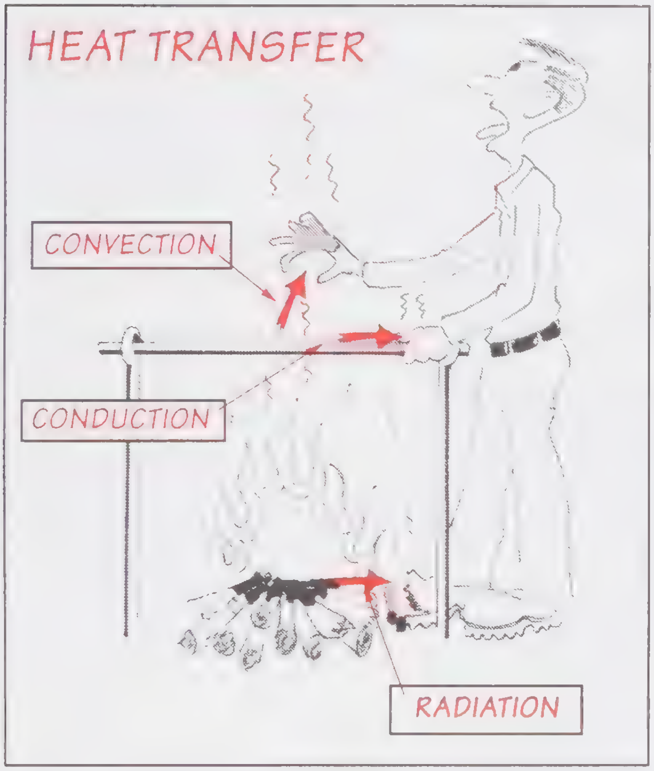


Figure 4.5 The three methods of heat transfer are present here. The camper may burn his right hand when convective heat raises; radiated heat will keep him warm but is responsible for the hole in his shoe; conductive heating is burning his left hand as he grabs the hot metal bar.

Firebrands

Wildland fires also spread by spotting. Spotting occurs when burning material is carried ahead of the fire and deposited in unburned material (Figures 4.8 through 4.11). If the firebrand is hot enough when it lands, a small fire will be started. Firebrands are moved by four different forces:

- Popping
- Convection
- Winds
- Gravity

Have you ever been next to a campfire when the fire "popped," and burning embers jumped from the fire? This type of firebrand is usually a short-range problem, but can cause a fire to move across firelines. The popping is a mechanical event. Moisture in the wood is heated and a small steam explosion occurs, throwing a burning piece of wood away from the fire.

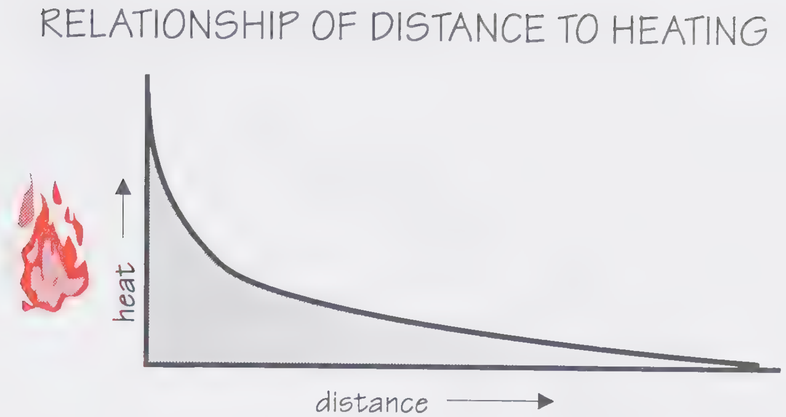


Figure 4.6 The farther you are from a heat source the less heat will be transferred.

The amount of heat transfer is directly related to the distance between the heat source and the fuels.

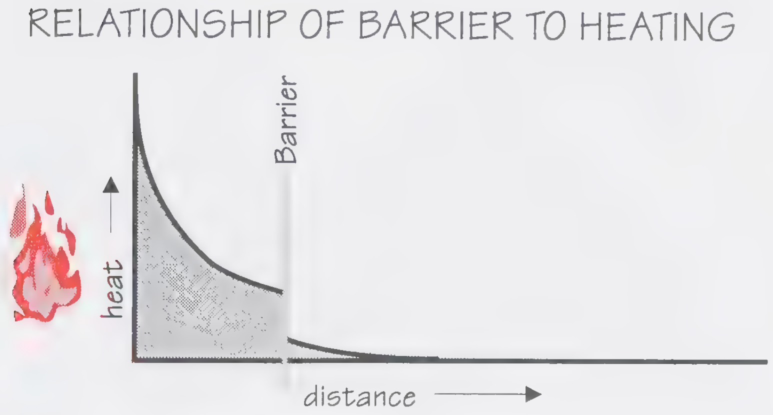


Figure 4.7 Even the thinnest barrier will reduce the amount of radiated heat transfer significantly.

Radiated heat is easily blocked.

A bigger problem is firebrands that are lifted by convective heating and dropped some distance ahead of the main fire. As a fire increases in intensity, so does the "lifting force" of its convection column. If the fuels being consumed are of such a nature that they develop firebrands (wood-shake roofs, oak leaves, etc.), the amount of material thrown into the air can be considerable. There is usually very little spotting during a grass fire, because grass is too light a material to develop firebrands.

When firebrands are lifted by a convection column, spotting may occur.

Wind can also pick up firebrands and move them some distance. Winds alone will not move firebrands great distances, because this effect is usually a horizontal action. The exception to this is fire whirls. Fire whirls are small cyclones sometimes present during unstable conditions, that can pick up burning

The convection column will lift the firebrands; the wind will then move them out in front of the fire.

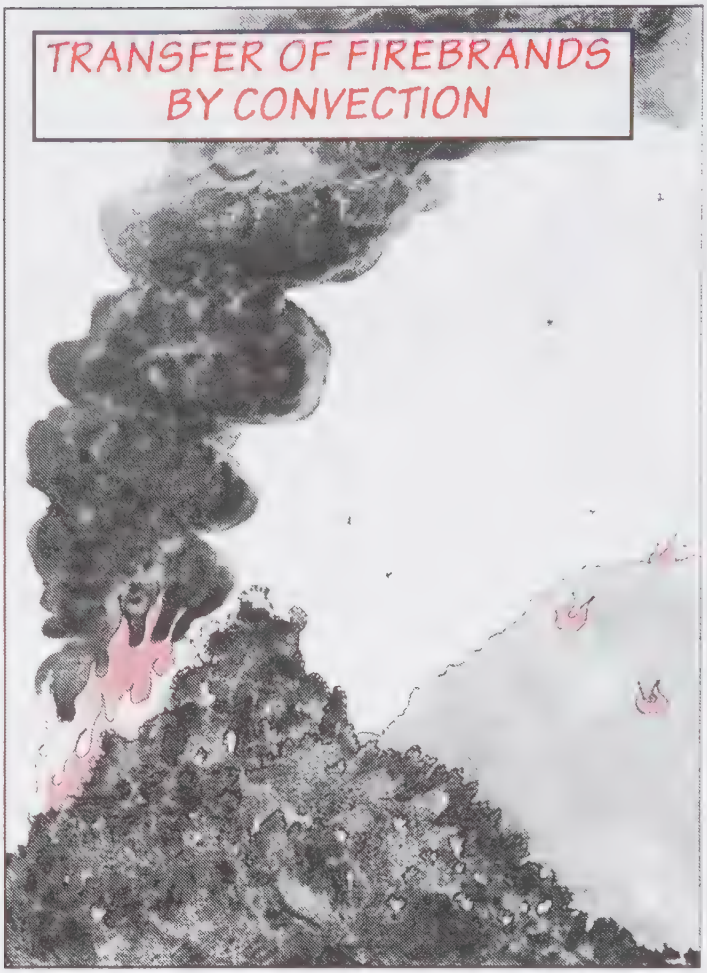

TRANSFER OF FIREBRANDS BY CONVECTION

Figure 4.8 If a convection column is strong enough, it will lift burning material and deposit it across firelines.

In steep terrain, gravity may be involved in the spread of the fire.

material and transport it some distance. Winds in combination with convection can be a real problem; convection lifts the burning material high into the atmosphere, where the winds are able to carry it some distance. In the northern hemisphere, there is a counter-clockwise movement of air as it rises. This means that there will be a higher percentage of spot fires on the left side of the fire's head.

Gravity can also spread a fire by moving burning material, especially if the material is round. Burning pine cones or logs are most affected by gravity. It is not uncommon that as the ground litter is burned away, burning material is dislodged and begins to roll down hill (Figure 4.12).

Ignition

Ignition of wildland fuels requires an ignition source. There are many such sources: lightning, discarded matches and cigarettes, campfires, debris burn piles, sparks from an exhaust system, etc. The source must be hot enough to heat the fuels to the point of ignition and produce self-sustaining combustion. Combustion usually occurs at about 500° in wildland fuels. The primary factors which affect the ignition of wildland fuels are:

- **Size and shape of the fuels** - The smaller/finer they are the easier they are to ignite.

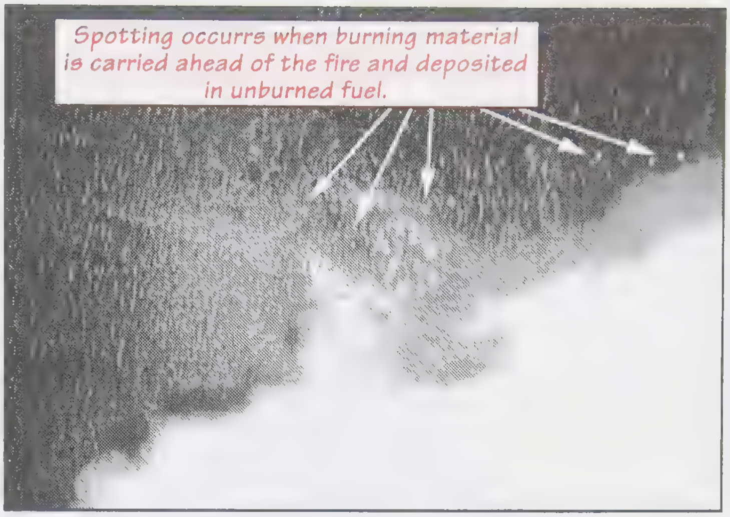

Spotting occurrs when burning material is carried ahead of the fire and deposited in unburned fuel.

Figure 4.9 This fire is spotting because the convection column is lifting firebrands and depositing them across the fireline. Surface wind doesn't appear to be a factor in this spotting.

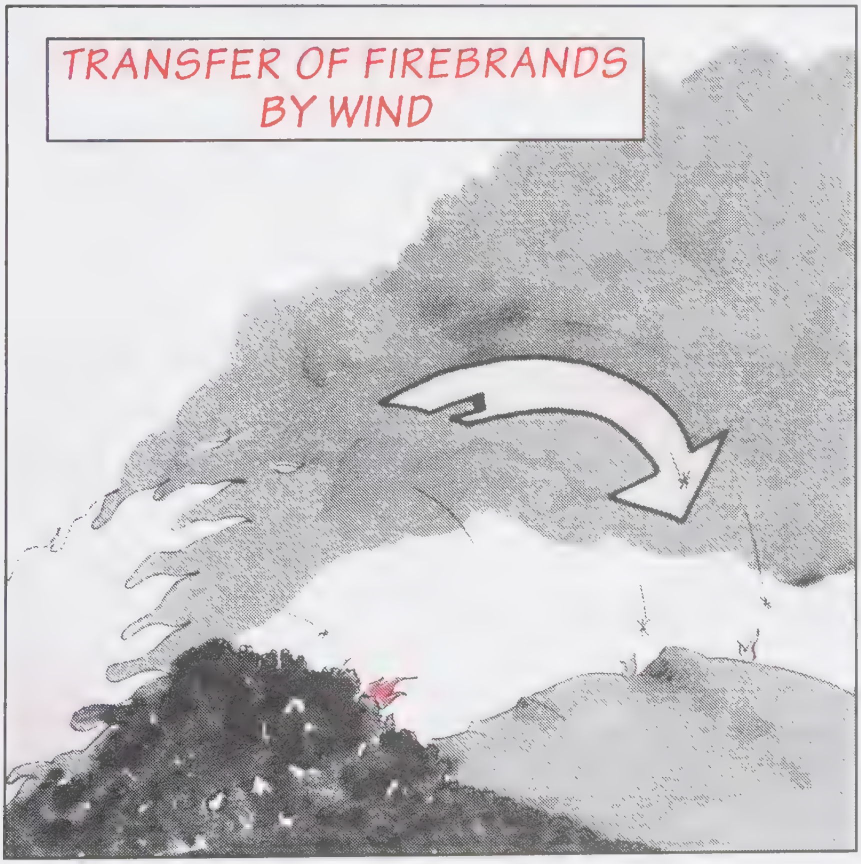

TRANSFER OF FIREBRANDS BY WIND

Figure 4.10 Wind can also play a part in moving burning material across firelines.

The size, shape, compactness, fuel moisture content, and temperature all affect how easily a fuel will ignite.

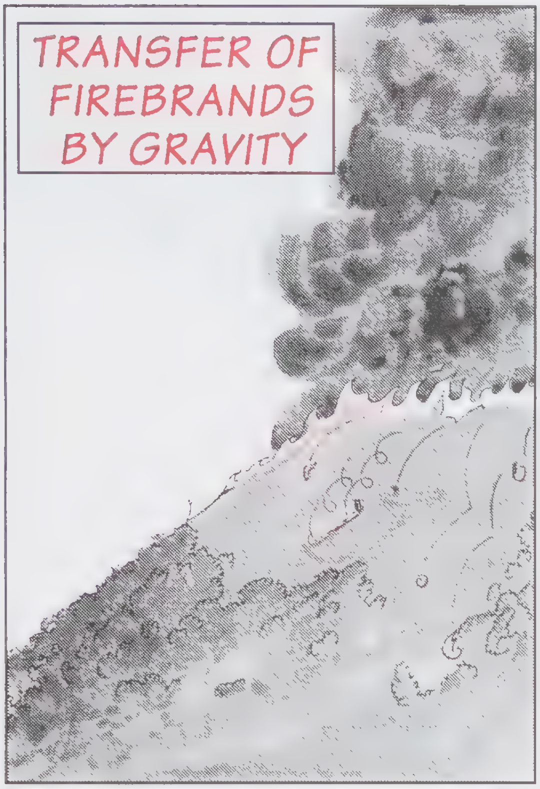

TRANSFER OF FIREBRANDS BY GRAVITY

Figure 4.11 Gravity can also spread a fire.

- **Compactness or arrangement of the fuels** - If they are loose and open, they will ignite easier.
- **Fuel moisture content** - The drier they are, the easier they are to ignite, because heat is not expended to drive the moisture out.
- **Fuel temperature** - The warmer the fuel, the less heat it takes to bring it to its ignition point.

Fire Intensity

Fire intensity is the rate of heat energy released during combustion. Fire intensity is measured in two ways: fireline intensity and flame length. Fireline intensity is the amount of heat released per foot of fire front per second (Figure 4.13). It is measured in British Thermal Units (A British Thermal Unit or BTU is the amount of heat required to raise the temperature of one pound of water one degree Fahrenheit). Flame length is the distance measured from the average flame tip to the base of the flame in the middle of the flaming zone. Fire intensity is affected by:

- **Fuel loading** - The amount of fuel available to burn.
- **Compactness or arrangement of fuels** - If the fuels are tightly arranged, with little space for air or convected heat to move, the fire will be less intense.

The amount of fuel, arrangement, fuel moisture content, slope, and wind affect the level of fire intensity.

Figure 4.12 Rolling material is spreading this fire down the hill.

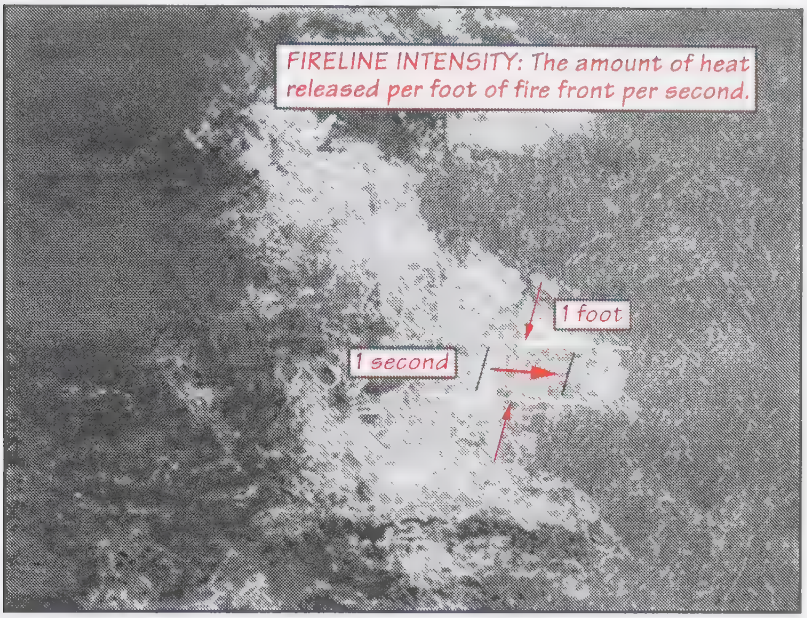

FIRELINE INTENSITY: The amount of heat released per foot of fire front per second.
1 foot
1 second

Figure 4.13 Fireline intensity is the amount of heat that is released per foot of fire front per second.

A BTU is the amount of heat required to raise the temperature of one pound of water one degree.

- **Fuel moisture content** - If a considerable amount of heat is needed to decrease the fuel moisture content sufficiently to allow for combustion, the fire will burn with less intensity.
- **Slope and wind speed** - Fires burn more intensely moving upslope or downwind, because convective heating is more efficient.

Note how some of the same factors affect both fire intensity and ignition.

Rate of Spread

There are several factors that influence the fire's rate of spread and burn pattern or shape:

- **Fire intensity** - If the intensity increases, so does the heat generation and the rate of spread.
- **Wind speed** - The stronger the wind, the more lean it puts on the convection column, and the faster the rate of spread.
- **Slope** - The steeper the slope, the closer the convection column is to the fuel and the faster the rate of spread.
- **Fuel type changes** - If the fire burns from one fuel type to another (grass to brush, timber slash to standing timber, etc.), the rate of spread will change, thereby affecting the burn pattern.
- **Natural or man-made barriers that stop or slow the spread** - Roads, streams, lakes, rock outcroppings, etc. will all affect the burn pattern.

Rate of spread is controlled by fire intensity, wind speed, slope, fuel type, spotting, and presence or absence of barriers in the path of the fire.

- **Spotting** - If the fire is generating spot fires ahead of or below the fire, the burn pattern will be affected.

A fire burning in uniform fuels on flat ground, with the wind being the only variable, burns with predictable elliptical shaped patterns. There is a ratio between the wind speed and the length and width of the burn pattern. These patterns also hold true when slope is the only variable. Figure 4.14 outlines the shapes of burn patterns for several wind speeds, as well as the ratios between wind speed and the rate of spread.

Wildland fires burn in predictable patterns.

Vertical Dimension

When trying to predict how far a fire will spread, you usually think in two dimensions: width and length. But, there is a third dimension, the vertical dimension, that must be considered (Figure 4.15).

As the fire develops in size or intensity, it involves an ever-growing three dimensional area. There are three factors that control the development of this third dimension:

- **Fire intensity** - The fire heats the air, causing it to rise through the atmosphere. Usually, the hotter the fire, the higher the heat (smoke) column will rise. As the hot air rises, cooler air from the surrounding areas will be drawn inward towards the fire to fill the void. These "indrafts" can actually fan the fire, increasing the intensity even more. When a fire burns with high intensity, it can change the environment around it. It is common for an intense fire to generate thunderclouds with lightning and strong winds. On the other hand, if the fire is of low intensity, both the "indraft" and smoke column will be weak. There will be little or no change in the local environment, because the environment is controlling the development of the fire.
- **Stability of the air** - Stability or instability is a major factor in the vertical dimension of the fire. If the air is unstable, with lots of vertical movement, the fire will easily develop a vertical component (Figure 4.16). However, a strong inversion layer will act as a lid over the fire, restricting its vertical development.

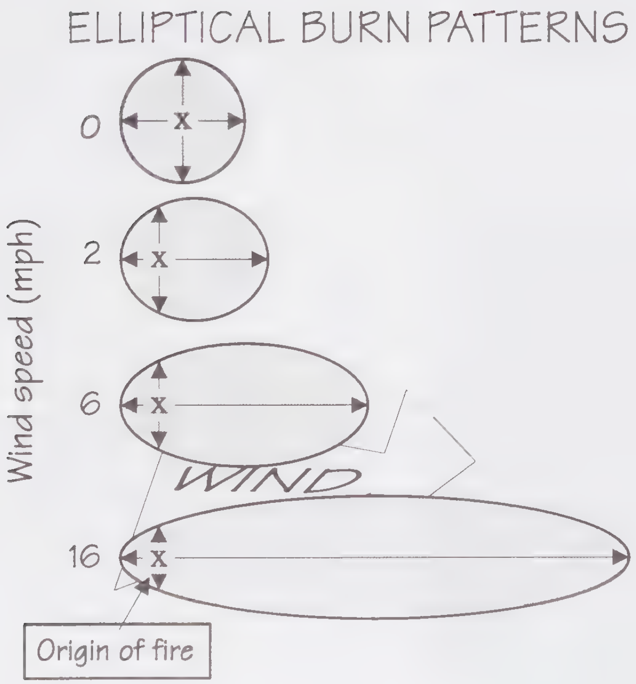


Figure 4.14 Wildland fires generally burn in elliptical patterns. Wind will change the general shape of the ellipse.

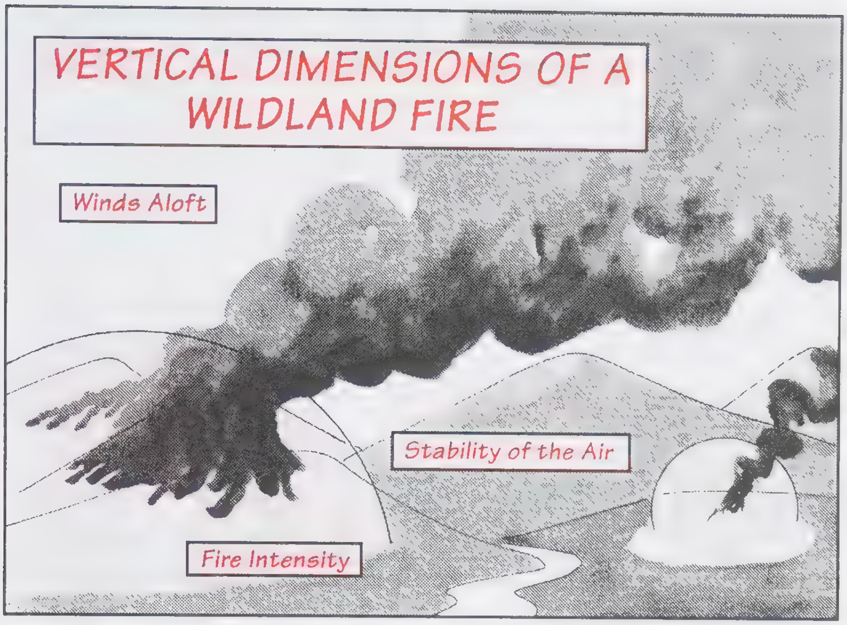


Figure 4.15 As a fire evolves, it can develop a third dimension. The extent of this development is controlled by fire intensity, the stability of the air, and the strength of winds aloft.

There is a vertical or third dimension to wildland fires. Three factors control the development of this vertical dimension: fire intensity, stability of the air, and the winds aloft.

- **Winds aloft** - Strong upper-level winds tend to limit the vertical development of a fire. They cut off the vertical movement of the convective heat (smoke) column.

Open and Closed Fire Environments

Another factor that controls the development of a fire is the localized fire environment. A fire burning in an open fire environment has a greater chance of reacting to the various weather elements than one within a closed forest canopy. A fire under a closed forest canopy may be limited in development, because the weather factors that can cause the fire to develop cannot penetrate and affect the fire. If such a fire was to develop and break through the canopy, there could be a dramatic increase in the fire's behavior.

As we have discussed, there are many factors that can affect the development of a wildland fire. You need to understand and consider all of them in the development of your firefighting strategy and tactics.

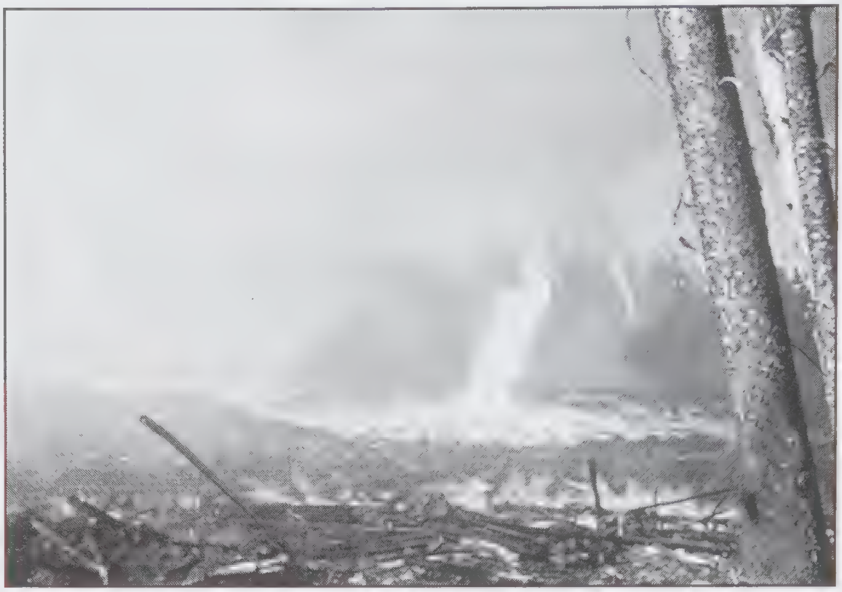


Figure 4.16 The fire whirl in this picture indicates that the air is very unstable.

Fire whirls only occur when the air is unstable.

Direction of Spread

Why does a fire burn in a particular direction? We've been taught that wind pushes a fire, and that a fire burns up a slope faster than on level ground. But, more specifically, the reason a fire burns in a particular direction hinges on the "presentation of the fuel." Did you ever "experiment" with the wick of a candle at Christmas time and cause a perfectly shaped candle to develop a "leak?" In messing with the wick of the candle, you changed the relationship of the heat source to the fuel. The spot where the candle began to "leak" received more heat, thus melting the wax faster (Figure 4.17).

A closed forest canopy can help limit the intensity of a fire on the forest floor.

There are three factors that influence the direction a fire will burn: wind, slope, and condition of the fuel. The three are closely related, though they spread a fire in different ways. Wind "pushes" or bends the fire, bringing the radiated and convective energy closer to the fuel bed. Slope brings the fuel closer to the heat source. Meanwhile, the fuel condition determines how vulnerable it is to fire. The drier the fuel, the more readily it will ignite.

Fire moves in a particular direction, because the heat source is closer to some fuels than others. Once the closer fuels ignite, the fire tends to move in that direction. In the chapter on topography, you learned that changes in topography can often provide a fire break. Fire will move up a slope fairly quickly, because the slope brings the fuels closer to the fire. Yet, once the fire reaches the ridge line the fuels start falling away from the heat source. The fire may stop moving in that direction. In comparison, picture the fuel presentation in a draw. Both the slope of the draw and the increased slope of the draw walls bring the fuel closer to the fire. Fire moving up through a draw can move extremely fast (Figure 4.18).

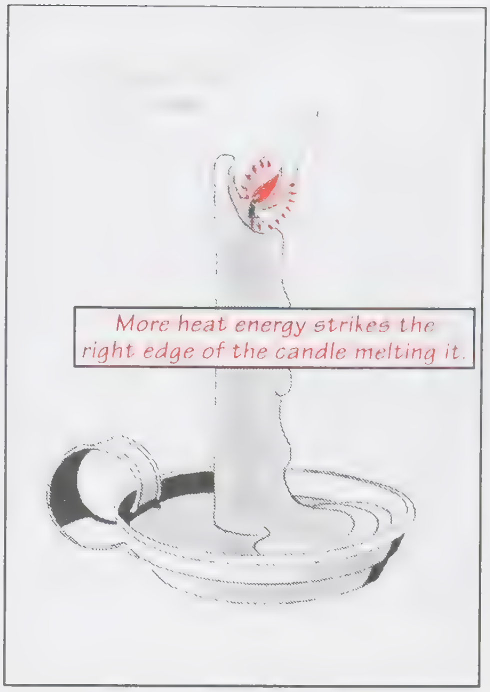

More heat energy strikes the right edge of the candle melting it.

Figure 4.17 The side where the candle began to leak received more heat than the rest of the candle.

Fire Behavior Characteristics

Fire behavior characteristics determine how and where you should fight fire, as well as the strategy and tactics you should use (Figure 4.19). The rate of spread and the flame length have a lot to do with the overall fire behavior. These fire behavior characteristics also dictate the level of firefighter safety. The greater the rate of spread and/or flame length, the greater the need to be vigilant.

Rate of spread and flame length are interrelated. If the rate of spread increases, so does the flame length and fire intensity. (However, flame length does not necessarily dictate rate of

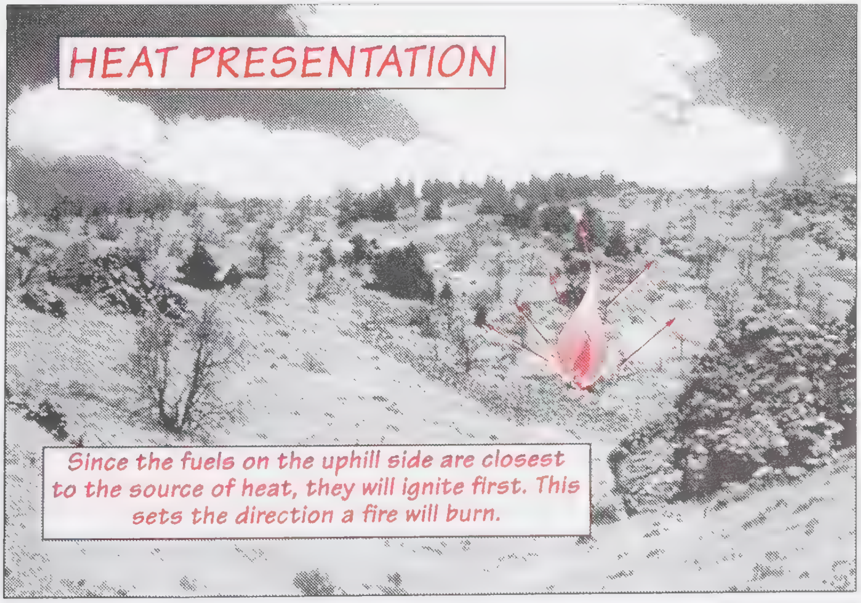

HEAT PRESENTATION
Since the fuels on the uphill side are closest to the source of heat, they will ignite first. This sets the direction a fire will burn.

Figure 4.18 The "presentation of fuels" controls the direction the fire will burn.

A fire moves in a particular direction, because the fuels in that direction are ignited first!

spread.) Let's take a closer look at how these factors influence one another. As the rate of spread increases, it generates more heat energy. However, the *heat per unit area* doesn't change. Heat per unit area is defined as the amount of heat energy released from the fuel covering one square foot of ground during the passage of the flame front (Figure 4.20). It remains constant for a given fuel type and fuel moisture content. If the fire is generating more heat energy, but the heat per unit area doesn't change, something else has to. The element that changes is the flame length. Flame length increases as the rate of spread increases. Flame length is a visual indicator of the surface fire intensity.

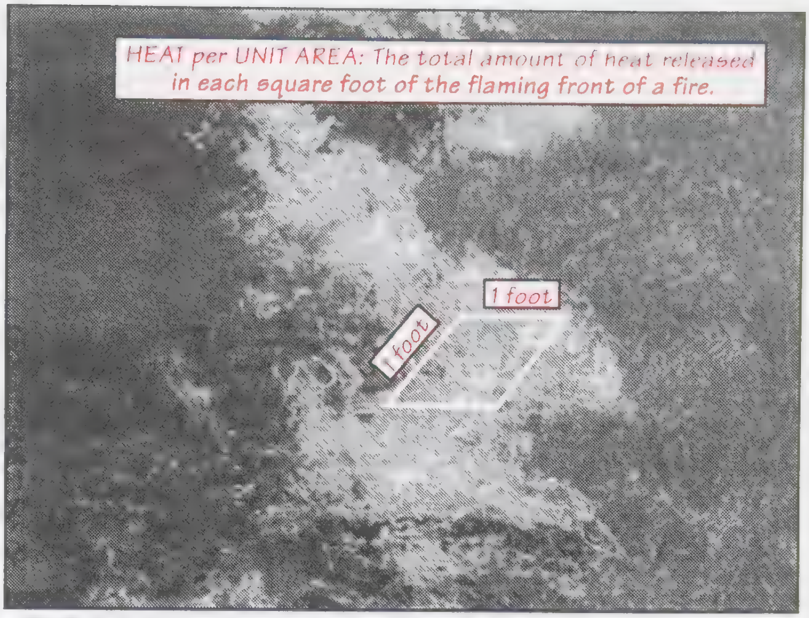
Fire suppression interpretations from flame length

Flame Length	Interpretations
Less than 4 feet	Fires can generally be attacked at the head or flanks by firefighters using hand tools. Handline should hold fire.
4 to 8 feet	Fires are too intense for direct attack on the head with hand tools. Handline cannot be relied upon to hold the fire. Bulldozers, engines, and retardant drops can be effective.
8 to 11 feet	Fires may present serious control problems: torching, crowning, and spotting. Control efforts at the head will probably be ineffective.
over 11 feet	Crowning, spotting and major fire runs are probable. Control efforts at the head of the fire are ineffective.

Figure 4.19 The length of the flame will give you a good indication of the problems you will have in suppressing the fire.

The length of the flame will dictate how you will fight a fire.

Once again, fire behavior characteristics impact your strategy and tactics. For example, if a high rate of spread will carry a fire to a ridge faster than you can construct a fireline, you will have to either pick another location for the fireline or start a flanking attack. If the flame length is over four feet, it will pretty much eliminate hand tools as a method of control. Rate of spread, fire intensity, and flame length all respond to changes in fuel type, moisture content, slope, and wind speed. You will see more about how these factors are interrelated as we continue.



HEAT per UNIT AREA: The total amount of heat released in each square foot of the flaming front of a fire.

Figure 4.20 Heat per unit area is the rate of heat release in each square foot of the flame front of a fire. Heat per unit area remains constant for a fuel type and fuel moisture.

The fire characteristics chart was developed to show the relationship between rate of spread, flame length, heat per unit area, and fire intensity. Remember, heat release per unit area remains constant for a given fuel type and moisture content. Therefore, once you determine the type and moisture content of the fuel you're dealing with, you can quickly determine changes in rate of spread and flame length.

There are two types of fire characteristics charts: one for light fuels (Figure 4.21) and one for heavy fuels (Figure 4.22). The relationships between the various factors are the same, but the scales are different. The little figures on the chart provide a quick reference to fireline limitations. These charts are sometimes referred to as the "haul charts," meaning you can haul hand tools, you can haul bulldozers, or you should "haul ass."

Rate of spread and flame length are interrelated.

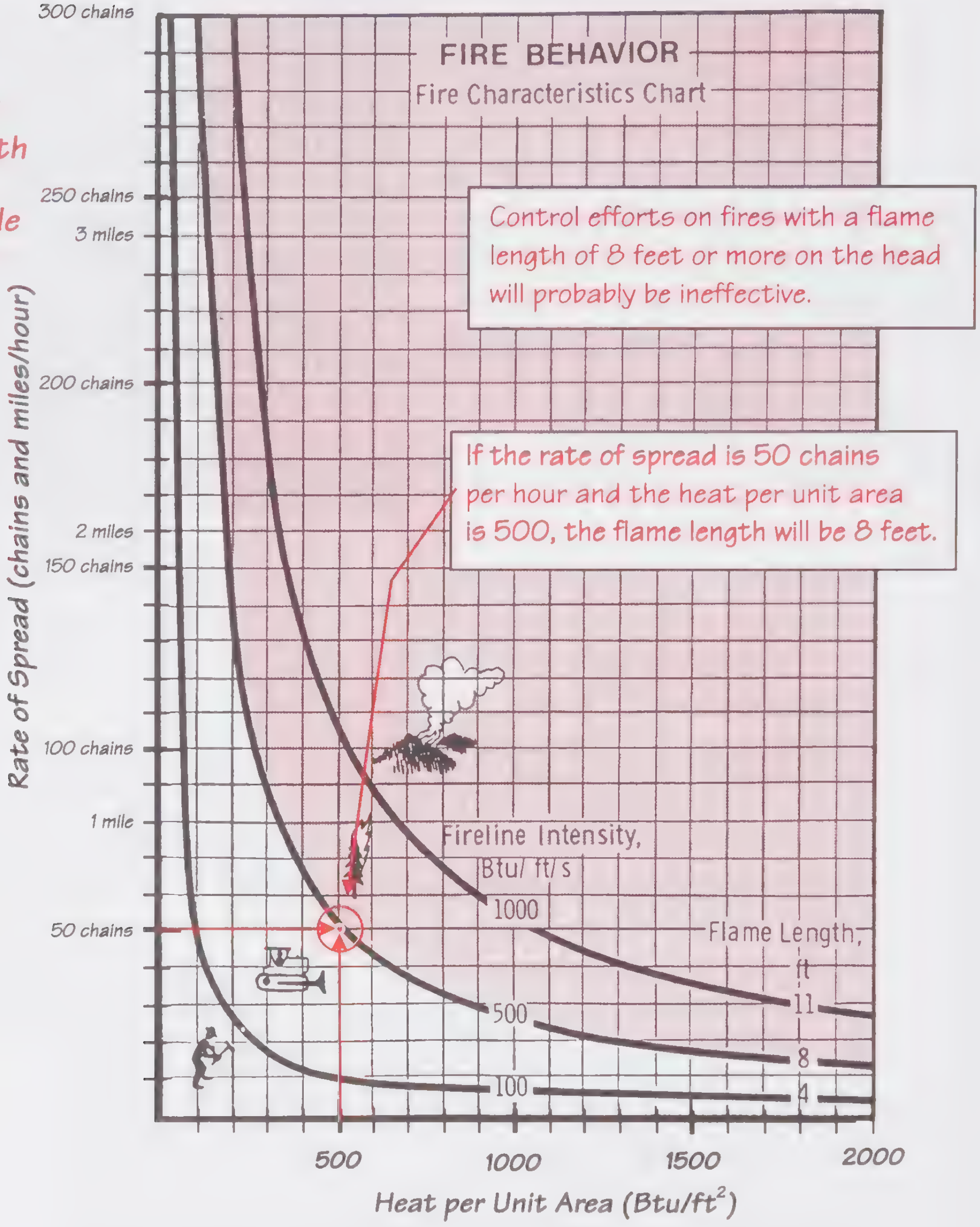
Surface Fire Intensity

Typical energy release from woody portions (cellulose and lignin) of wildland fuels is about 8,000 BTUs per pound. If the fuel contains resins, oils, or waxes, this can add significantly to the energy output. This energy is released during combustion, with most of it going into the rising convection column or radiating in all directions. A small portion (usually less than 20 percent) is effective in heating unburned fuels. The unburned fuels are "heated" by radiated heat generated from the flaming zone of the fire. If there is a wind, or the fire is burning on a slope, convective heat and direct flame contact play a part in the heating of unburned fuels. The relationship between the flame zone and unburned fuel is changed in the same way by a 50 percent slope or a 5 mile per hour wind (Figures 4.23 and 4.24).

The "haul charts" have real meaning. Use them.

FIRE CHARACTERISTICS CHART (Light Fuels)

Note how the rate of spread, and flame length are related to fire intensity and applicable suppression tactics.



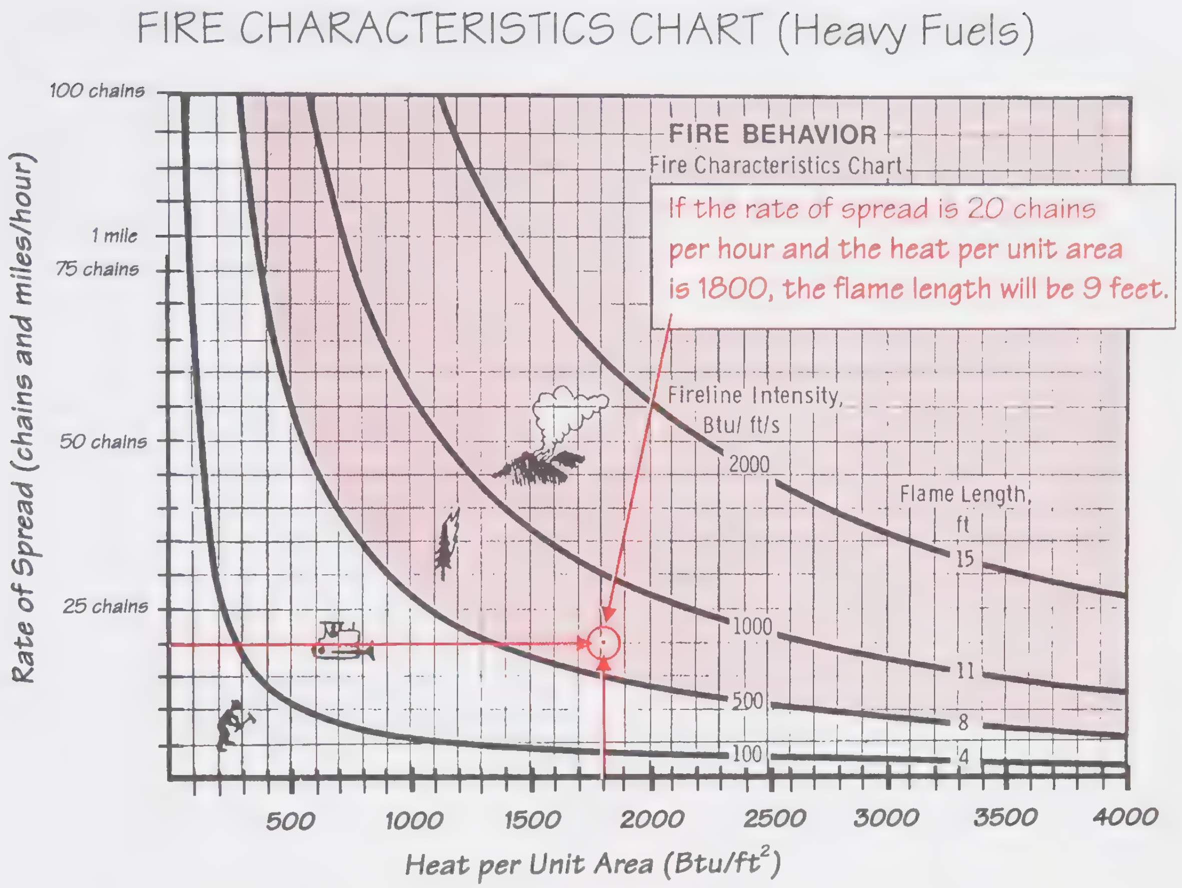
Control efforts on fires with a flame length of 8 feet or more on the head will probably be ineffective.

If the rate of spread is 50 chains per hour and the heat per unit area is 500, the flame length will be 8 feet.

Figure 4.21 Fuel Characteristics Chart (Light Fuels) - Note the relationship of rate of spread and heat per unit area to flame length.

Wildland fuels can release up to 8,000 BTUs per pound.

The rate at which unburned fuels are preheated changes based on fuel type, its moisture content, fuel temperature, etc. If the intensity of the fire increases, the rate at which a fuel is preheated increases. Increased heat production by the fire, more



If the rate of spread is 20 chains per hour and the heat per unit area is 1800, the flame length will be 9 feet.

Figure 4.22 Fuel Characteristics Chart (Heavy Fuels) - This example shows that fire in heavy fuels with a rate of spread of 20 chains per hour, and a heat per unit area rating of 1800, will have a flame length of about 9 feet.

efficient heat transfer, and a reduction in the amount of heat required for ignition, will increase the rate of spread.

Less than 20% of heat energy reaches unburned fuels.

Effects that Changes in Fuels, Wind, and Slope have on Fire Behavior

There are several physical fuel properties that directly affect fire behavior: fuel loading, live-to-dead fuel ratio, surface area-to-volume ratio, compactness, and orientation. These factors are generally fixed for a given fuel bed. Two other important factors are fuel moisture content and fuel temperature, both of which can change hour-by-hour.

The **fuel moisture content** is the most influential of the varying factors. Figure 4.25 shows the impact a change in fuel moisture has on rate of spread and flame length. When the fuel

The vast majority of heat energy released by a wildland fire goes into the atmosphere.

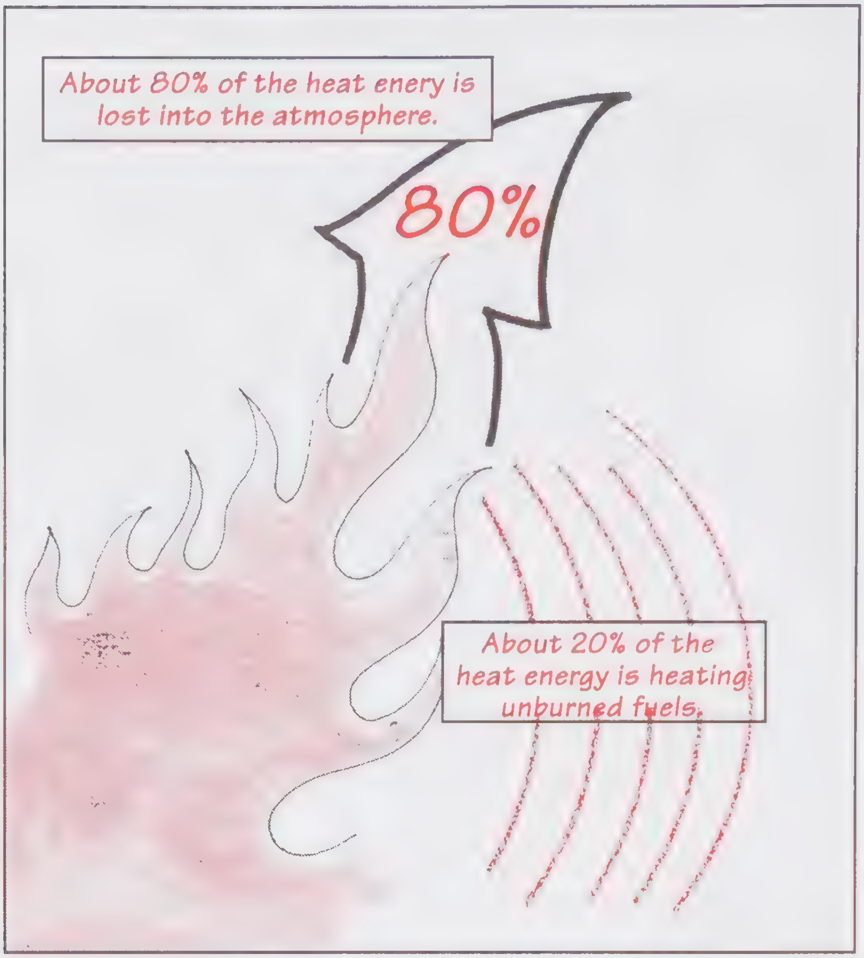

About 80% of the heat enery is lost into the atmosphere.
80%
About 20% of the heat energy is heating unburned fuels.

Figure 4.23 Heat is transferred to unburned fuels by radiation from the flame zone. However, most of the heat energy is released into the atmosphere.

moisture content is higher, it takes more heat energy to drive out the moisture and ignite the fuel. The process of driving out or evaporating the moisture actually cools the fuel, increasing the heat energy required for ignition.

Fuel moisture content and temperature can change hour-by-hour.

Once again, fine fuels are the primary carrier of wildland fires, and are also the most "reactive" to changes in relative humidity and fuel moisture content. Figure 4.26 shows the changes in rate of spread and flame length, if you vary the 1-hour fine dead fuel moisture.

Changes in **live fuel moisture** also have a major effect on fire behavior. However, even if the live fuel moistures are high, fire behavior can be considerable if a high dead-to-live fuel ratio, steep slopes, or a brisk midflame wind are involved. Figure 4.27

shows how a variation in live fuel moisture content changes rate of spread and flame lengths.

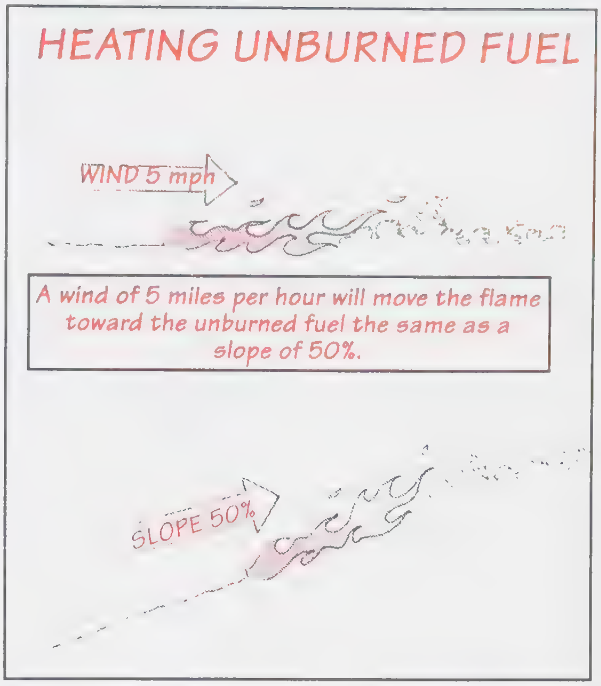

HEATING UNBURNED FUEL
WIND 5 mph
A wind of 5 miles per hour will move the flame toward the unburned fuel the same as a slope of 50%.
SLOPE 50%

Figure 4.24 Slope and wind change the relationship between the flame zone and the unburned fuels. A 50 percent slope and 5 mile per hour wind have the same effect on "moving" the flame zone closer to unburned fuels.

As you already know, wind has one of the more dramatic effects on fire behavior. It is the dominant factor when it comes to changes in the rate of spread in light fuels. Doubling the wind speed can more than double the rate of spread. Wind has less of an effect in heavier fuels like logging slash (Figure 4.28).

Earlier in the chapter, we said that wind "pushes" or bends the fire, bringing the radiated heat and convective energy closer to the fuel bed. It also provides a good supply of oxygen to the fire. If you were to plot some of these changes on the fire characteristics chart, you would see the relationship between flame length and rate of spread (Figure 4.29). Let's look at three examples. (You will learn how to calculate the actual flame length and rate of spread later. For now, it is sufficient to understand how the two factors are related.)

Example 1: The windspeed is 2 miles per hour, and the rate of spread is 39 chains per hour. (One chain equals 66 feet). The flame length will be 8 feet.

Example 2: If the wind increases to 4 miles per hour, the rate of spread will increase to 89 chains per hour, and the flame length will be 12 feet.

A wind of 5 mph has the same effect as a slope of 50%.

Example 3: At a wind speed of 8 miles per hour, the fire will burn at a rate of 214 chains per hour with an 18-foot flame length.

Note that the heat per unit area remains constant at 750 BTUs per square foot, because there haven't been any changes in fuel type or moisture content.

Doubling the wind speed doubles the rate of spread.

Earlier in the chapter, we also said that fires have a greater rate of spread on slopes than they do on flat terrain, because the fire is closer to the fuels on the uphill side of the slope. Radiation heat transfer is higher in this area; thus the unburned fuels are ignited more quickly. Convective heat transfer may also play a

HOW CHANGES IN FUEL MOISTURE IMPACT FIRE BEHAVIOR

	Higher moisture content decreases fire behavior	Lower moisture content increases fire behavior
1-hour moisture (%)	12	3
10-hour moisture (%)	13	4
100-hour moisture (%)	14	5
live fuel moisture (%)	170	70
midflame wind speed (mph)	4	4
slope (%)	30	30

As fuel moisture decreases, fire behavior increases.

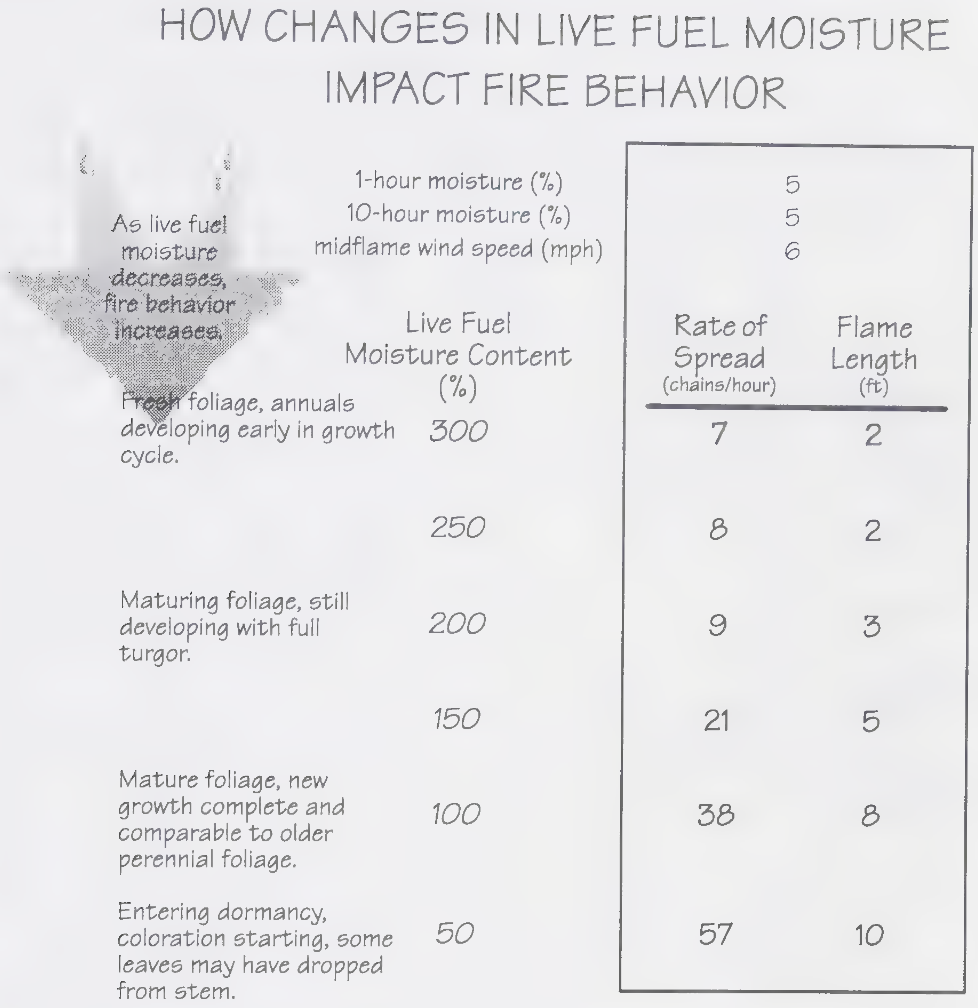
		Higher moisture content decreases fire behavior		Lower moisture content increases fire behavior	
Fuel Group	General Orientation	Rate of Spread (chains/hour)	Flame Length (ft)	Rate of Spread (chains/hour)	Flame Length (ft)
Grass	*Vertical*	<1 - 75	<1 - 10	40 - 140	5 -16
Shrub	*Vertical*	5 - 22	2 - 7	33 - 100	7 - 24
Timber Litter	*Horizontal*	1 - 5	1 - 2	2 - 11	1 - 6
Logging Slash	*Horizontal*	3 - 11	2 - 9	7 - 21	4 - 13

Figure 4.25 As fuel moisture content changes, the rate of spread and flame length are changed.

HOW CHANGES IN 1-HOUR FUEL MOISTURE IMPACT FIRE BEHAVIOR

	Higher moisture content decreases fire behavior			Lower moisture content increases fire behavior		
	1-hour fine dead fuel moisture	**Rate of Spread** (chains/hour)	**Flame Length** (ft)	1-hour fine dead fuel moisture	**Rate of Spread** (chains/hour)	**Flame Length** (ft)
Short Grass	10%	20	2	2%	53	4
Tall Grass	10%	49	9	6%	96	14
Shrub	10%	44	15	2%	63	20
Timber Litter	10%	3	2	2%	6	3
Logging Slash	10%	7	6	2%	13	9

Figure 4.26 If the 1-hour fine dead fuel moisture changes, it can have a dramatic impact on fire behavior.



HOW CHANGES IN LIVE FUEL MOISTURE IMPACT FIRE BEHAVIOR

1-hour moisture (%) 5
10-hour moisture (%) 5
midflame wind speed (mph) 6

As live fuel moisture decreases, fire behavior increases.

	Live Fuel Moisture Content (%)	Rate of Spread (chains/hour)	Flame Length (ft)
Fresh foliage, annuals developing early in growth cycle.	300	7	2
	250	8	2
Maturing foliage, still developing with full turgor.	200	9	3
	150	21	5
Mature foliage, new growth complete and comparable to older perennial foliage.	100	38	8
Entering dormancy, coloration starting, some leaves may have dropped from stem.	50	57	10

Figure 4.27 The effects of changes in the live fuel moisture on fire behavior.

part in this effect, especially on steeper slopes. If the slope triples from 8% to 24%, the rate of spread will triple from 5 chains/hour to 14 chains/hour. With a second tripling of the slope, the rate of spread will increase by 4 to 6 times. Figure 4.30 shows the impact that changes in slope have on rate of spread and flame length. You can use the fire characteristics chart to see the relationship between flame length and rate of spread and a changing slope (See Figure 4.29).

As noted above, both slope and wind act in the same way on rate of spread and heat transfer. If the wind and slope are "aligned," or running in the same direction (an upslope wind), then the effective midflame wind speed is higher than the wind speed itself. Figure 4.31 is an effective windspeed graph for

As fuel moisture content decreases, fire behavior will increase.

HOW CHANGES IN MIDFLAME WIND IMPACT FIRE BEHAVIOR

	Weaker midflame wind, decreases fire behavior			**Stronger midflame wind, increases fire behavior**		
	Midflame Wind (mile/hour)	Rate of Spread (chains/hour)	Flame Length (ft)	Midflame Wind (miles/hour)	Rate of Spread (chains/hour)	Flame Length (ft)
Short Grass	2	18	2	4	61	4
Tall Grass	2	39	8	4	89	12
Shrub	2	30	13	4	72	20
Timber Litter	2	2	2	4	6	3
Logging Slash	2	6	5	4	11	7

Figure 4.28 If the midflame wind changes, it will have a significant impact on fire behavior.

Live fuel moistures can be as high as 300%.

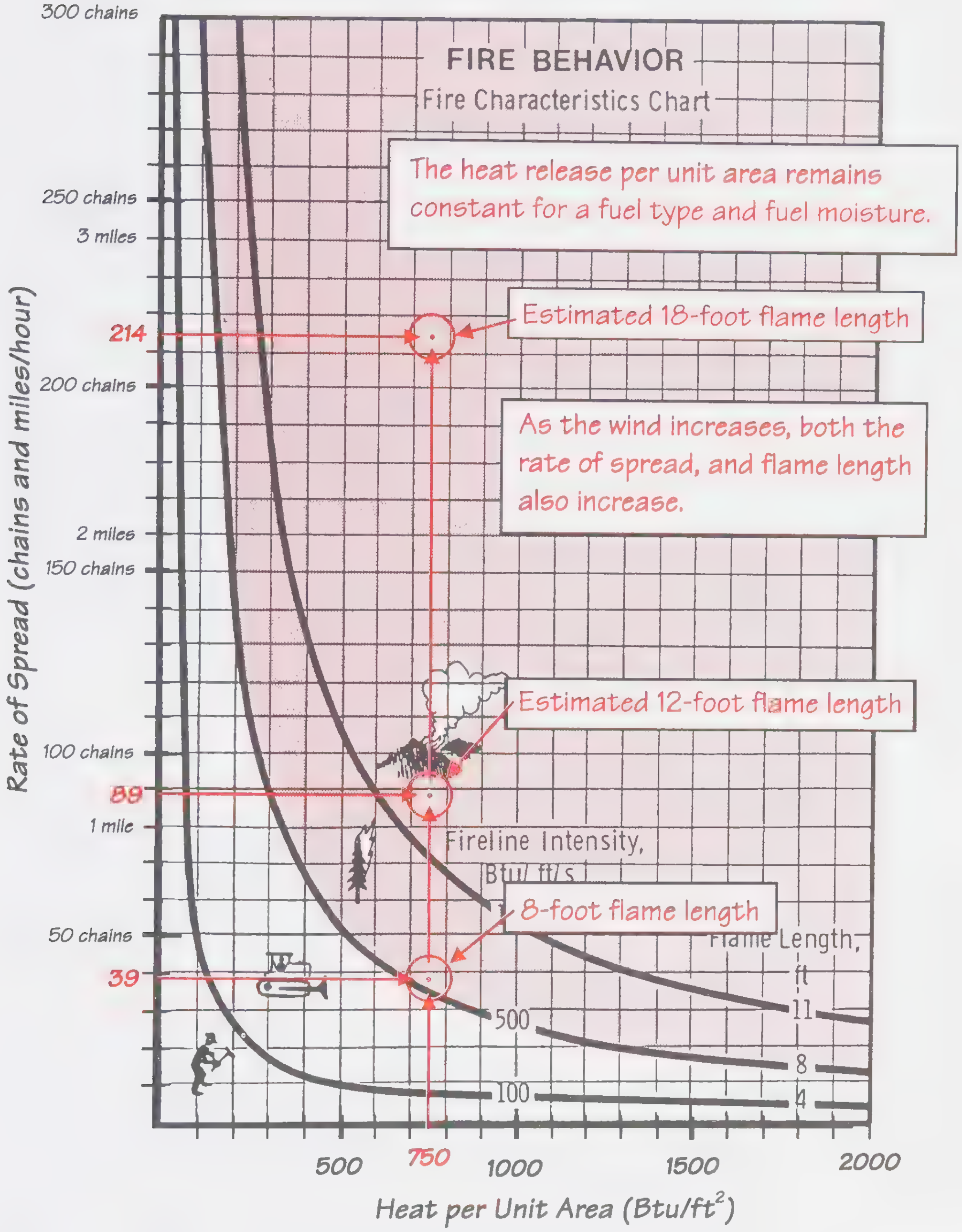
If wind and slope are "aligned," the effective midflame wind speed is higher than the wind speed itself.

timber type fuels. It shows the adjustment for slope and wind. Note, if the midflame wind is a 5 mile per hour upslope wind on a 60% slope, the effective midflame wind is adjusted to 7 miles per hour. The midflame wind speed lines curve gets steeper (greater effective wind speed) as the slope percent increases. If we had a 5 mph midflame wind on an 80% slope, the effective wind speed would be closer to 8 mph. If the slope was only 20%, the effective wind speed would still be about 5 mph.

The effect of slope is greatest at low wind speeds. If we keep the 60% slope, but drop the midflame wind speed to 2 mph, the effective wind speed is 5 mph. If we increase the midflame wind speed to 15 mph, the effective wind speed will be 16 mph. The greatest difference occurred at the lower wind speed. The effect of slope on fire behavior is generally considered less significant than the effect of wind, even on steep slopes. Doubling the midflame wind speed has much more effect than tripling the slope.

If there is a downslope or cross-slope wind, the relationship between wind and slope becomes complex. If there is a strong

WIND'S EFFECT ON FLAME LENGTHS



The heat release per unit area remains constant for a fuel type and fuel moisture.

Estimated 18-foot flame length

As the wind increases, both the rate of spread, and flame length also increase.

Estimated 12-foot flame length

8-foot flame length

Figure 4.29 The effects of wind on fire behavior, plotted on the fire characteristics chart.

downslope wind, the fire will move downslope. If the downslope wind is light, the fire will move upslope. If there is a cross-wind from left to right, the fire will move up and to the right. The actual direction of spread will be influenced by the strongest effect. A wind of even a few miles per hour can overpower the

Slope has its greatest impact at low windspeeds.

HOW CHANGES IN SLOPE IMPACT
FIRE BEHAVIOR

	Flatter slope, decreased fire behavior			Steeper slope, increased fire behavior		
	Slope (%)	Rate of Spread (chains/hour)	Flame Length (ft)	Slope (%)	Rate of Spread (chains/hour)	Flame Length (ft)
Short Grass	8%	5	1	24%	14	2
Tall Grass	8%	6	3	24%	14	5
Shrub	8%	6	6	24%	14	9
Timber Litter	8%	1	1	72%	8	3
Logging Slash	8%	2	3	72%	13	8

Figure 4.30 If the slope changes, it will have an impact on fire behavior.

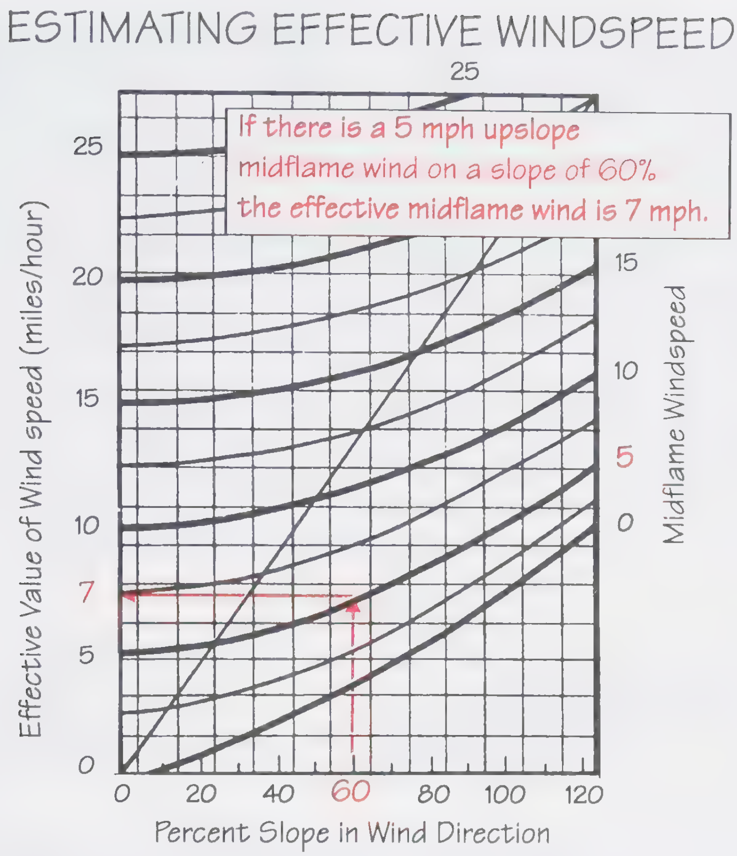
slope as the dominant force driving the fire; strong winds can produce rapid downslope spread. The wind may temporarily be dominating, but never forget that the wind direction can change. Slope is always of critical importance, especially when you are working above a fire on a slope.

Doubling the midflame wind speed has a greater impact than tripling the slope.

Fire Behavior Prediction

Fire behavior prediction involves the observation and analysis of multiple factors in the fire environment, both initially and on an on-going basis throughout the fire. The ability to predict fire behavior is critical to your success as a fire officer. This doesn't mean that you have to become a fire behavior analyst, but you need to be able to anticipate how a fire will progress, and with what speed and intensity. Before we proceed to a formal discussion of fire behavior, we will discuss the potential behavior of various fuel types.

A wind of even a few miles per hour can overpower the effect of slope.



If there is a 5 mph upslope midflame wind on a slope of 60% the effective midflame wind is 7 mph.

Figure 4.31 Slope changes the effect of midflame winds. If you have a 5 mile per hour upslope midflame wind on a 60% slope, the effective midflame wind is adjusted to 7 miles per hour.

Fire Behavior Fuel Models

Wildland fuels come in many types and sizes, all of which burn differently. There are 17 fuel types which range from grass and bear clover, to light-to-medium chamise, to woodland. For the sake of simplification, we will combine these fuel classifications into four major fuel groups: grass, shrub, timber litter, and logging slash. The size, shape, arrangement, compactness, chemical content, and fuel moisture vary within each of these major groupings. To further help in defining the potential fire behavior that can be anticipated when a fire burns in these fuels, the groups have been divided into 13 specific fire behavior fuel models. (Note: Do not confuse the 13 fire behavior models that will be described below with the 17 fuel types).

If you can't predict fire behavior, how can you expect to select the right suppression strategy?

There are 13 fire behavior fuel models.

There are three fire behavior fuel models in the grass group. Grass is the primary carrier of fire. Fuel beds vary in depth from 1 to 2½ feet in depth. Fuel loading can range from 300 pounds per acre to over several tons per acre. The fuel moisture in grasses responds very quickly to changes in relative humidity. Fire behavior can range from low intensity to rapid rate of spread (up to several miles an hour), when pushed by a strong wind.

Fire Behavior Fuel Model 1

Grass (Fire Behavior Fuel Model 1) - Fire spread is governed by the fine fuels that have cured or are nearly cured. These fires are surface fires that move rapidly through cured grass and associated material. Very little shrub or timber is present, generally less than $^1/_3$ of the area (Figure 4.32).

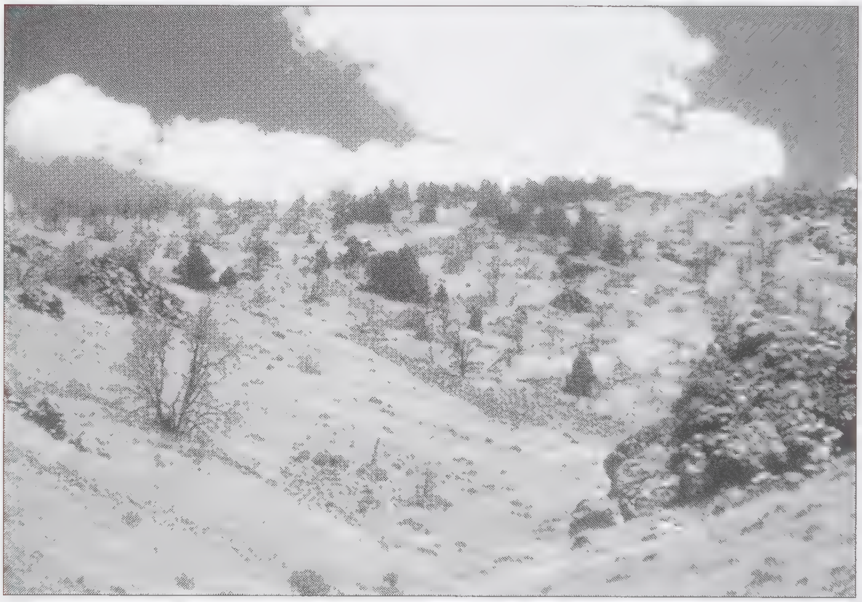


Figure 4.32 Fire Behavior Fuel Model 1 - Grass, savanna, and stubble.

Grass, with some shrub and trees (Fire Behavior Fuel Model 2) - Fire spread is primarily through the fine fuels, either curing or dead. These are surface fires that burn grasses, ground litter, and dead-down stemwood from the open shrub or timber overstory. Shrub or timber generally covers from $^1/_3$ to $^2/_3$ of the area. This model may also include clumps of fuels that generate higher intensities and may produce firebrands (Figure 4.33).

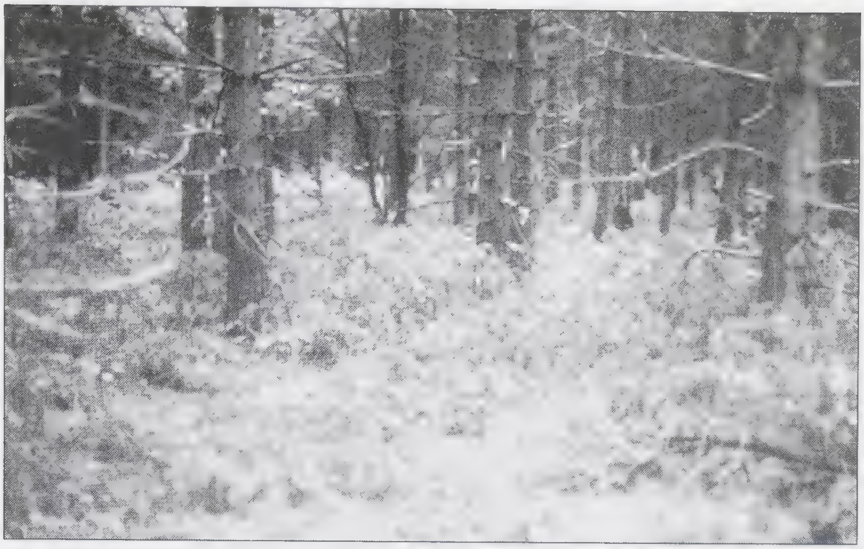


Figure 4.33 Fire Behavior Fuel Model 2 - Grass with less than $^2/_3$ open shrub or trees scattered throughout the area.

Fire Behavior Fuel Model 2

Grass, intense burning under wind (Fire Behavior Fuel Model 3) - Fires in this fuel are the most intense of the grass group and display high rates of spread under the influence of wind. The fire may be driven into the upper heights of the grass stand by the wind, and may even cross over standing water. Stands are tall, averaging about 3 feet, but considerable variation may occur. Approximately $^1/_3$ or more of the stand is considered dead or cured, and is capable of maintaining the fire (Figure 4.34).

There are four fire behavior fuel models within the shrub grouping. Shrub fuels also constitute a primary carrier of fire. The shrub group fuel bed ranges from 2 to 6 feet in depth. Fuel loading can range between 1 to 80+ tons per acre. The size and shape of the fuels vary, but they are normally under 1 inch in diameter. The fuels can be compacted in thin layers, or may be very deep. Live fuel moisture and chemical content are significant factors in how shrubs burn.

Fire behavior models help predict the potential behavior of variouls fuels.

Shrub, high intensity and fast burning (Fire Behavior Fuel Model 4) - This model involves high intensity fires that spread rapidly through the foliage and ignite woody materials in the crowns of a nearly continuous secondary overstory. Besides

Fire Behavior Fuel Model 3

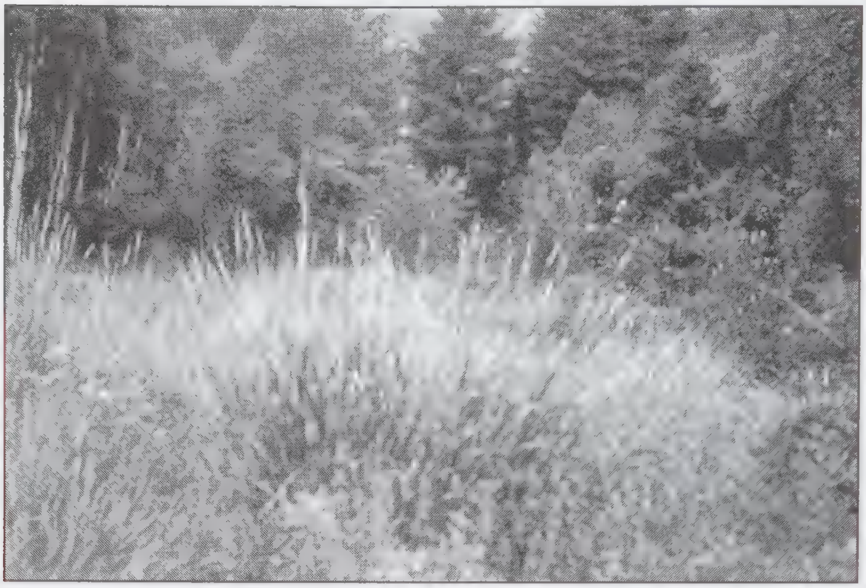


Figure 4.34 Fire Behavior Fuel Model 3 - Grass capable of supporting an intense fire driven by a wind.

the flammable foliage, there is dead woody material in the stand that significantly contributes to the fire intensity. There may also be a deep litter layer that hampers suppression efforts (Figure 4.35).

Shrub, low intensity ground fire (Fire Behavior Fuel Model 5) - In this model, fire is generally carried in the surface fuels made up of litter cast off by the shrubs and the grasses in the understory. Fires are generally not very intense because surface fuel loads are light, the shrubs are young with little dead material, and the foliage contains little volatile material. Shrubs are generally not tall, but may cover the entire area (Figure 4.36).

Shrub, wind driven (Fire Behavior Fuel Model 6) - Fires carry through the shrub layer, where the foliage is more flammable than Fire Behavior Fuel Model 5, but require moderate winds of at least 8 miles per hour at midflame height. Fire will drop to ground litter at lower wind speeds or where there are openings in the fuel. Shrubs are older (Figure 4.37), but not as tall or thick as shrub types in Fire Behavior Fuel Model 4.

Shrub, with flammable live fuels (Fire Behavior Fuel Model 7) - Fire burns through surface and shrub strata equally. Even the dead fuels with high moisture content burn easily, because of the flammable nature of the live foliage. Shrubs are generally 2 to 6 feet high (Figure 4.38).

There are three fire behavior fuel models within the timber group. The surface litter is the primary carrier of fire in this group. It can range in depth from a couple of inches to 1 foot. The fuel bed consists of mixed litter, leaves or needles, to large branches. The moisture content is retained if the fuel bed is compacted. The fire behavior of surface fires will range from slow burning to running, with some occasional torching of trees.

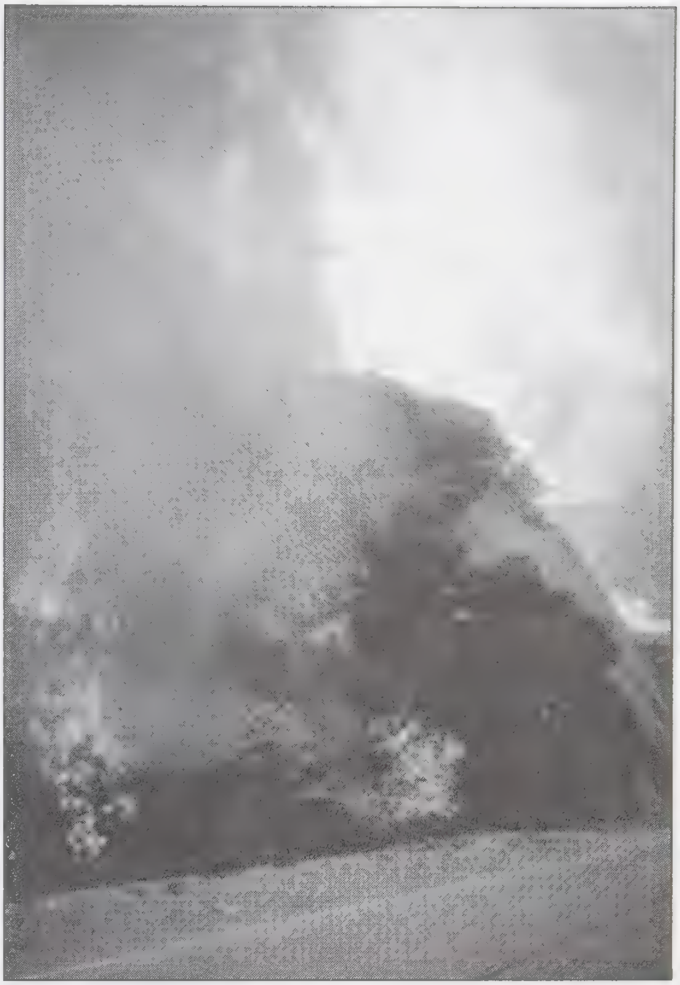


Figure 4.35 Fire Behavior Fuel Model 4 - Intense fire burning in chaparral, pine barrens, or Jack pine stands.

Timber, low intensity ground fire (Fire Behavior Fuel Model 8) - These fuels generally produce slow-burning ground fires with low flame heights, although an occasional heavy fuel concentration may cause a flare-up. They only pose fire problems under severe weather conditions. A fire in the compact litter layer will be supported by closed-canopy stands of short needle conifers or hardwoods that have leafed out (Figure 4.39).

Fire Behavior Fuel Model 4

Timber, moderate intensity ground fire (Fire Behavior Fuel Model 9) - Fires run through the surface a little faster than in Model 8, and have higher flame heights. Concentrations of dead-down woody material contribute to possible torching of trees, spotting, and crowning activity (Figure 4.40).

Timber, intense ground fire, spotting, torching, and crown fires (Fire Behavior Fuel Model 10) - These fires burn in

Fire Behavior Fuel Model 5

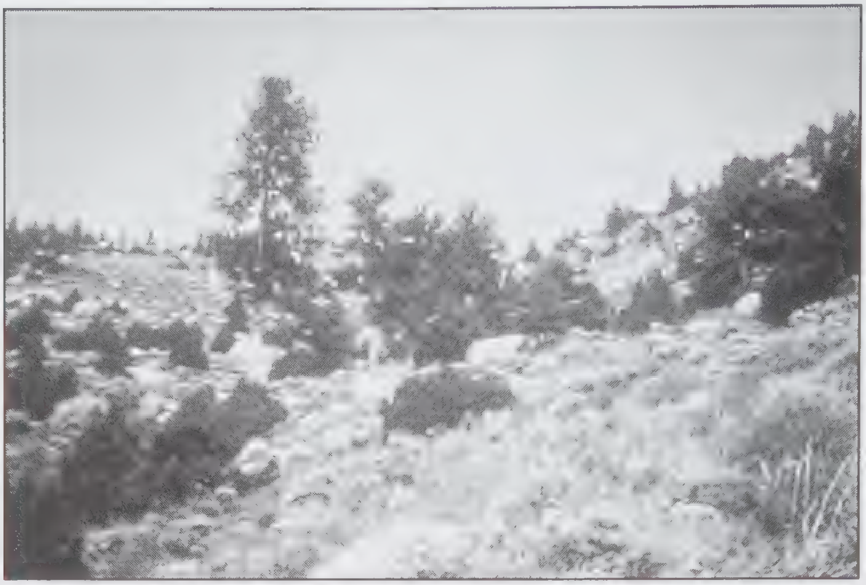


Figure 4.36 Fire Behavior Fuel Model 5 - Low intensity ground fire in maple, alder, or chaparral, and manzanita or chamise.

Fire Behavior Fuel Model 6

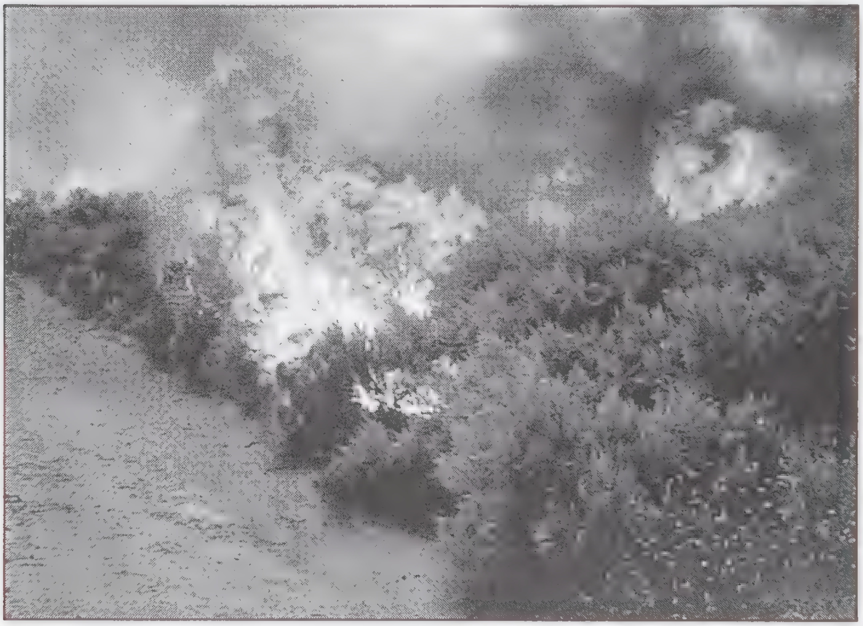


Figure 4.37 Fire Behavior Fuel Model 6 - Wind-driven fire in chamise, chaparral, oak brush, spruce, etc.

the surface and ground fuels with greater intensity than other timber litter models. Dead-down fuels include greater quantities of 3-inch or larger limb wood. Crowning out, spotting, and torching of individual trees are more frequent in this fuel situation, leading to potential fire control difficulties. Any forest type

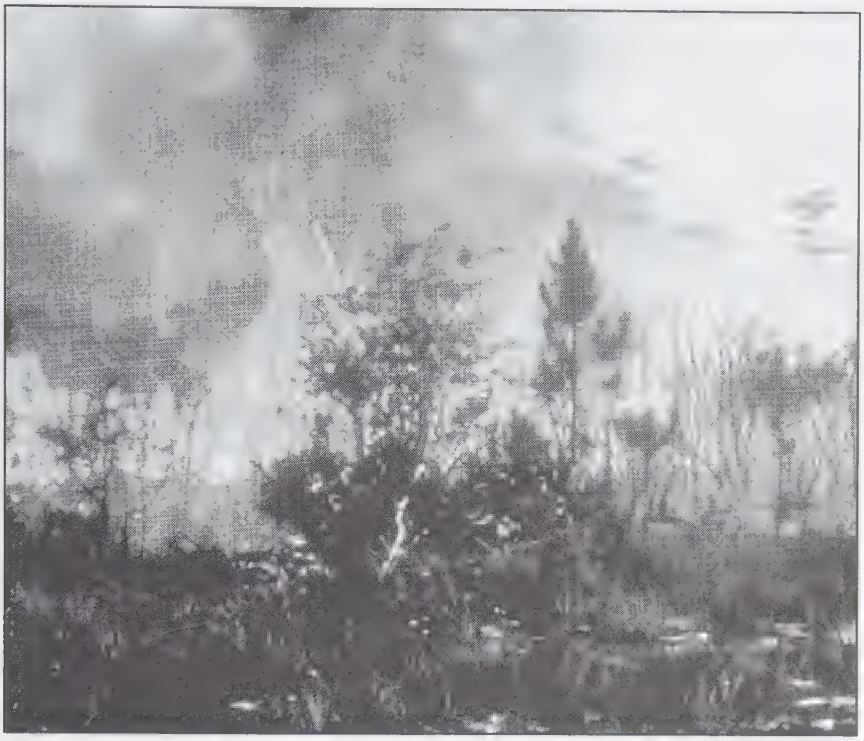


Figure 4.38 Fire Behavior Fuel Model 7 - Fire burns surface fuels and dead fuels with high moisture content, because of the flammability of the live foliage.

Fire Behavior Fuel Model 7

may be considered when heavy down materials are present (Figure 4.41).

There are three fire behavior fuel models within the logging slash group. Logging slash can range from 1 to 3 feet in depth. Fire behavior can range from moderate to rapid rate of spread. Slash fires may burn very intensely if the fuel arrangement is open. Firebrands may be generated and lifted by convective heat.

Logging slash, low intensity fire (Fire Behavior Fuel Model 11) - Fires are fairly active in the slash and other fuels that are intermixed with the slash. However, the fire potential is limited by the spacing of the rather light fuel load, shading from overstory, or the aging of the fine fuels. Clear-cut operations generally produce more slash than this model covers (Figure 4.42).

Fire Behavior Fuel Model 8

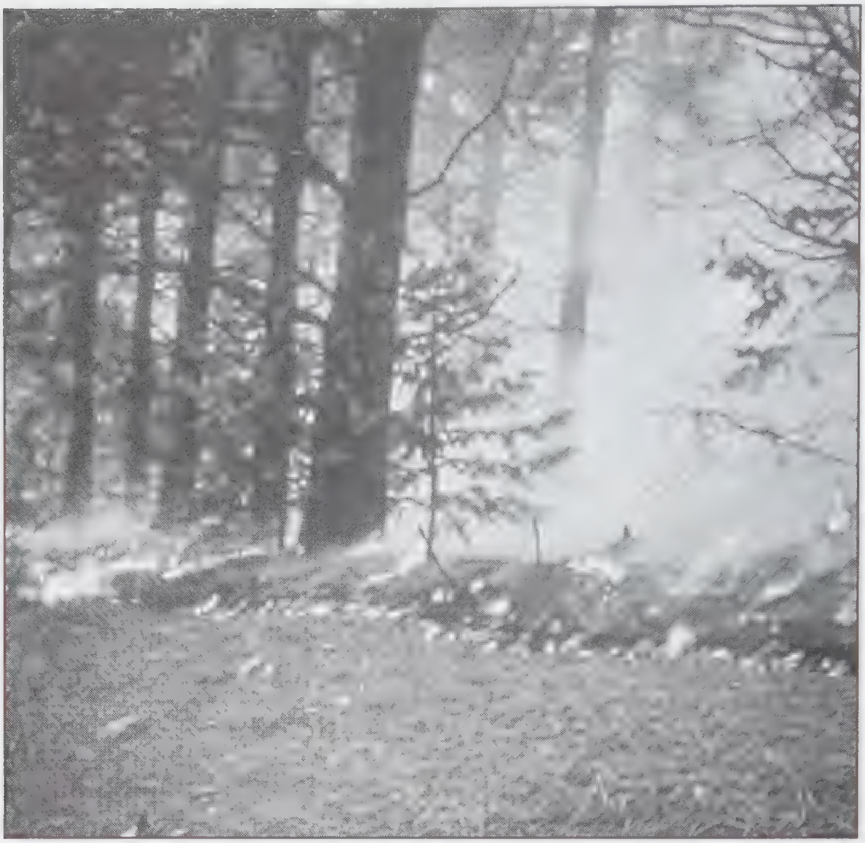


Figure 4.39 Fire Behavior Fuel Model 8 - Low intensity ground litter fire in stand of timber.

Fire Behavior Fuel Model 9

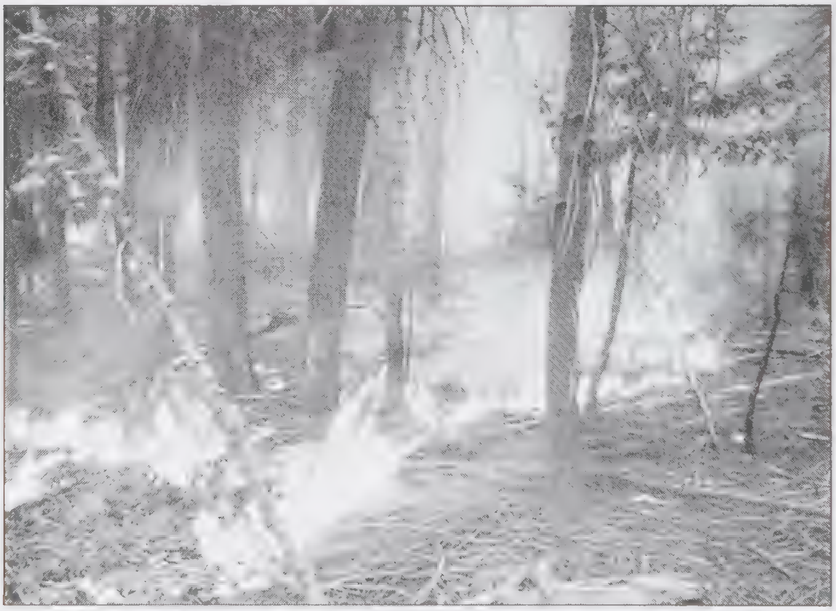


Figure 4.40 Fire Behavior Fuel Model 9 - Ground fire in a timber stand, with occasional torching and spotting.

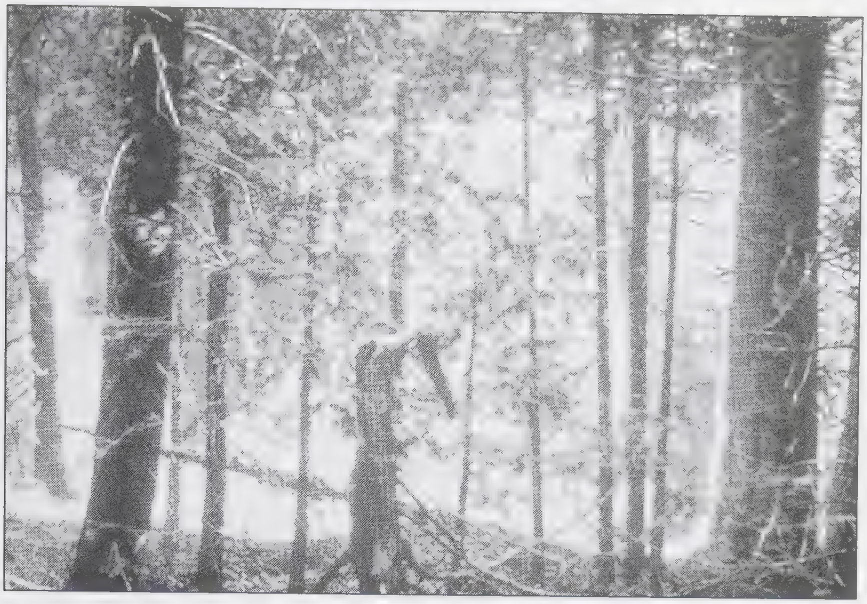


Figure 4.41 Fire Behavior Fuel Model 10 - Intense fire in timber fuels.

Fire Behavior Fuel Model 10

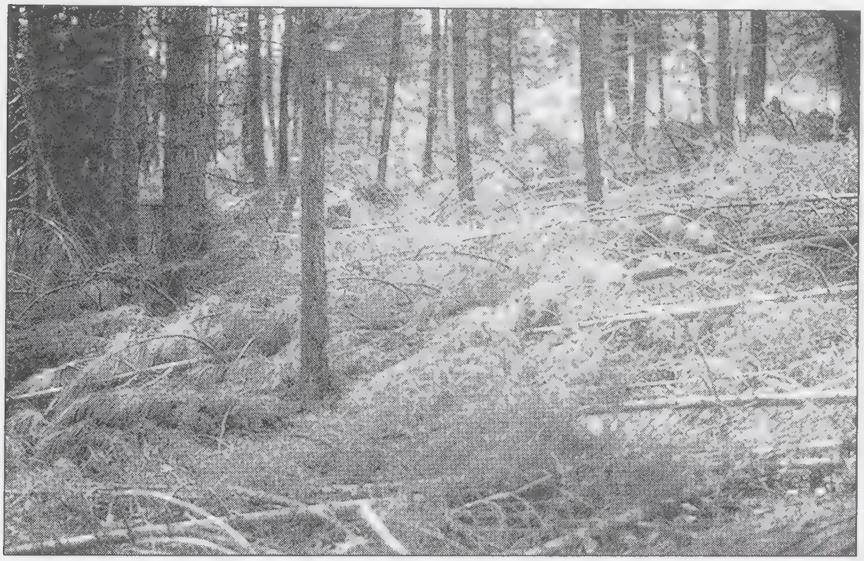


Figure 4.42 Fire Behavior Fuel Model 11 - Logging slash, low intensity fire.

Fire Behavior Fuel Model 11

Logging slash, high intensity fire (Fire Behavior Fuel Model 12) - These fuels can produce rapidly spreading fires with high intensities, capable of generating firebrands. When fire starts, it is generally sustained until a fuel break or change in fuels is encountered. The visual impression is dominated by slash, much of which is less than 3 inches in diameter. These fuels total less than 35 tons per acre and seem well distributed. Heavy thinned conifer stands, clear-cuts, and medium or heavy partial cuts are represented (Figure 4.43).

Fire Behavior Fuel Model 12

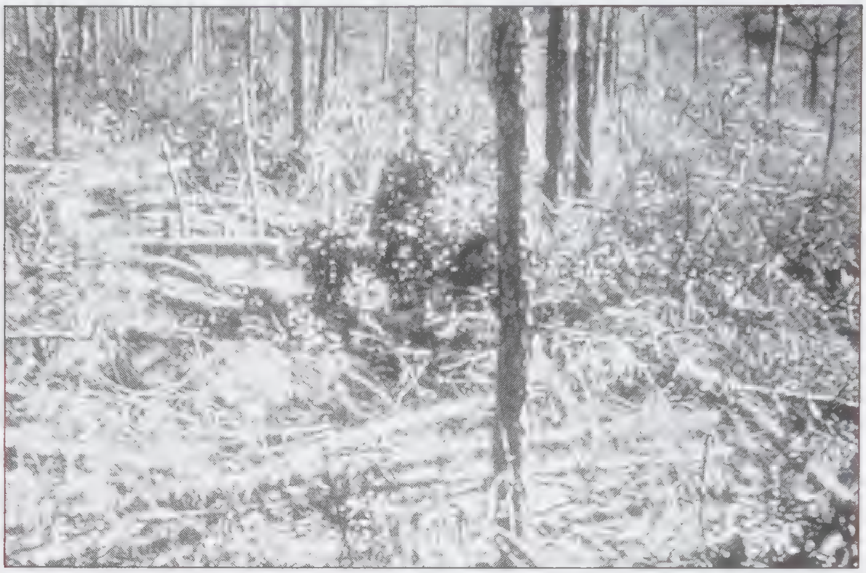


Figure 4.43 Fire Behavior Fuel Model 12 - Logging slash, high intensity.

Fire Behavior Fuel Model 13

Logging slash, heavy fuel loading, high intensity fire (Fire Behavior Fuel Model 13) - Fire is generally carried by a continuous layer of slash. Large quantities of over 3-inch fuels are present. Fires spread quickly through the fine fuels, and intensity builds up as the large fuels start to burn. Active flaming is sustained for long periods, and a wide variety of firebrands can be generated. These contribute to spotting problems as weather conditions become more severe (Figure 4.44).

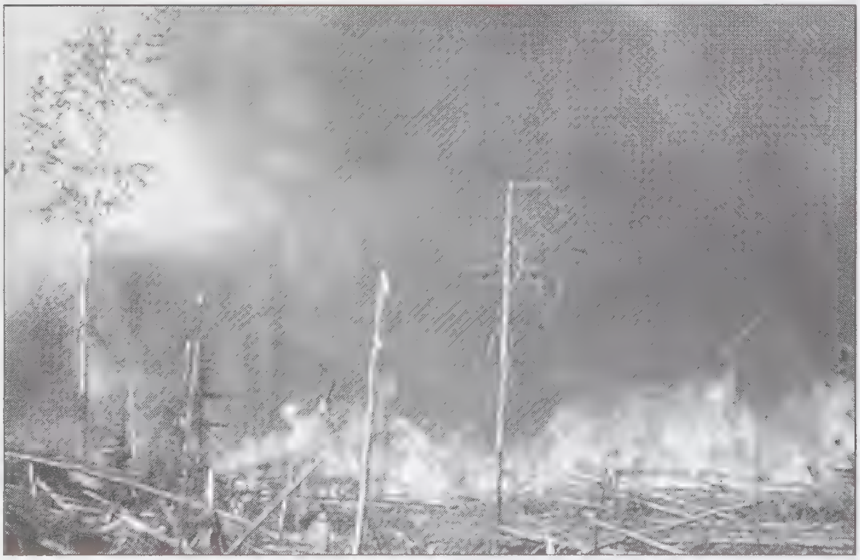


Figure 4.44 Fire Behavior Fuel Model 13 - Logging slash, heavy fuel loading, and high intensity fire.

Reference to these fire behavior models can help you predict fire behavior potential. Use this information when you are developing your strategy and tactics.

Fire Behavior Nomograms

One of the more formal ways of predicting fire behavior is with a **surface fire behavior nomogram**. The nomogram is a graphic presentation of mathematical fire spread models (Figure 4.45). There are 26 nomograms, two for each of the 13 fire behavior fuel models. They are divided into two categories: one for low wind speeds and one for high wind speeds. You should use the low wind speed nomogram whenever possible, because it gives more precise predictions. However, if the midflame wind speed exceeds the range of this nomogram, you will need to switch to the one for high wind speeds.

Nomograms can help you develop a fire behavior prediction.

The use of nomograms is a manual procedure. However, there is a computer program called "BEHAVE" that also develops fire behavior predictions. It uses the same mathematical fire spread models.

Like the art of weather prediction, fire behavior prediction is not an exact science. You're not going to get precise numbers; they are best estimates. Don't consider the results of any fire behavior prediction method, be it "eye balling it," use of a nomogram, or use of a computer, as absolute or final. These "aids" should be used to verify your professional judgment. Consider them a way to confirm or support your informed guess!

To use a nomogram you must input several pieces of information. They are the:

- **Fire behavior fuel model** - You must select the fuel model in which most of the burning is occurring. You may have a fire burning in brush, but if grass is the primary carrier of the fire, you should select a grass fuel model.
- **Midflame wind speed** - It is best if you can measure the actual midflame wind speed. However, you can estimate it if you know the 20-foot wind speed.
- **Percent of slope** - The slope may not be constant; try to average.
- **Fine dead fuel moisture** - This can be calculated if you know the relative humidity.
- **Live fuel moisture** - In most cases, this will have to be estimated.

SURFACE FIRE BEHAVIOR NOMOGRAM

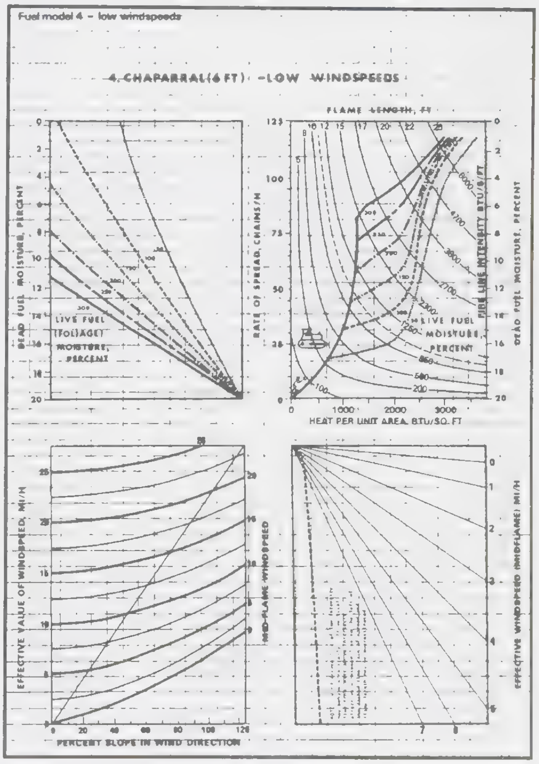


Figure 4.45 A surface fire behavior nomogram, usually just referred to as a nomogram, is a graphic presentation of a mathematical fire prediction model. There are 26 nomograms: two for each of the 13 fire behavior fuel models (one for low wind speeds and one for high winds).

The nomogram will provide output values for the:

- **Rate of spread**
- **Flame length**
- **Fireline intensity**
- **Heat energy per unit area**

Selection of a Fire Behavior Fuel Model

The first step in using a nomogram is to select the right fuel model. Nomograms are designed to describe the conditions at the head of a fire or the fire front. They are tied to the finer fuels that are carrying the fire. Most fires spread in a series of "runs" when conditions are favorable for burning; that is what the 13 fuel models are designed to simulate. Assessment of fire behavior will be simpler if a single fuel model can be found to describe the fuels in the area:

Nomograms do not predict spotting.

To select the most appropriate fuel model, you need to answer four general questions.

- What is the general vegetative type: grass, brush, timber, litter, or slash?
- What fuel is the primary carrier of the surface fire? Let's say, for example, that the fire is in a forested area. However, the timber is open, and dead grass, rather than needle litter, is the primary carrier of the fire. In this case, you would select a grass model rather than a needle model.
- What is the general depth and compactness of the fuel?
- Which fuel classes are present, and what will their influence on fire behavior be? Is there a predominance of green vegetation? Are there large, dead fuels?

It is important to select the right fuel model.

A fire behavior fuel model key has been developed to help you with this process. By comparing the written descriptions with what you see on the ground in front of you, you can determine the right fuel model. (Figure 4.46).

There are four parts to a nomogram. They are commonly referred to by their position on the chart: "upper left," "lower right," etc. (Figure 4.47). Once the nomogram has been "calibrated" by adjusting the midflame wind speed for slope and live fuel moisture, you start developing your fire behavior prediction in the upper right block. You work clockwise, back toward where

FIRE BEHAVIOR FUEL MODEL KEY

Use this key to aid in the selection of the most appropriate fuel model.

	Use Fuel Model
Primary carrier of the fire is GRASS. Expected rate of spread is moderate to high, with low to moderate intensity (flame length).	
☐ Grass is fine structured, generally below knee level, and cured to primarily dead. Grass is essentially continuous.	1
☐ Grass is coarse structured, above the knee level (averaging about 3 feet), and is difficult to walk through.	3
☐ Grass is usually under an open timber, or brush overstory. Litter from the overstory is involved, but grass carries the fire. Expected spread rate is lower than fuel model 1, and intensity is less than fuel model 3.	2
Primary carrier of the fire is BRUSH or LITTER beneath brush. Expected rate of spread and fireline intensity (flame length) are moderate to high.	
☐ Vegetation type is southern rough or low pocosin. Brush is generally 2 to 4 feet high.	7
☐ Live fuels are absent or sparse. Brush averages 2 to 4 feet in height. Brush requires moderate wind to carry fire.	6
☐ Live fuel moisture can have a significant effect on the fire behavior.	
☐ Brush is about 2 feet high, with light loading of brush litter underneath. Litter may carry the fire, especially at low wind speeds.	5
☐ Brush is head-high (6 feet), with a heavy loading of dead woody fuel. Very intense fire with high spread rates expected.	4
☐ Vegetative type is high pocosin.	4
Primary carrier of the fire is LITTER beneath a timber stand. Spread rates are low to moderate; fireline intensity (flame length) may be low to high.	
☐ Surface fuels are mostly foliage litter. Large fuels are scattered and lie on the foliage litter; large fuels are not supported above the litter by their branches. Green fuels are scattered enough to be insignificant to fire behavior.	
☐ Dead foliage is tightly compacted, short needles (2 inches or less), conifer litter or hardwood litter.	8
☐ Dead foliage litter is loosely compacted long needle pine or hardwoods.	9
☐ There is significant amount of larger fuel. Larger fuel has attached branches and twigs, or has rotted enough that it is splintered and broken. The larger fuels are fairly well distributed over the area. Some green fuel may be present. The overall depth of the fuel is probably below the knees, but some fuel, may be higher.	10
Primary carrier of the fire is LOGGING SLASH. Spread rates are low to high; fireline intensity (flame length) is low to very high.	
☐ Slash is aged and overgrown.	
☐ Slash is from hardwood trees. Leaves have fallen and cured. Considerable vegetation (tall weeds) has grown in amid the slash, and has cured or dried out.	6
☐ Slash is from conifers. Needles have fallen, and considerable vegetation (tall weeds and some shrubs) has overgrown the slash.	10
☐ Slash is fresh (roughly 0 - 3 years) and not overly compacted.	
☐ Slash is not continuous. Needle litter or small amounts of grass or shrubs must be present to help carry the fire, but the primary carrier is still slash. Live fuels are either absent or do not play a significant role in fire behavior. The depth is about 1 foot.	11
☐ Slash generally covers the ground (heavier loading than Model 11), though there may be some bare spots or areas of light coverage. Average slash depth is about 2 feet. Slash is not excessively compacted. Approximately one-half of the needles may still be on the branches, but are not red. Live fuels are absent, or are not expected to affect fire behavior.	12
☐ Slash is continuous or nearly so (heavier loading than model 12). Slash is not excessively compacted, and has an average depth of 3 feet. Approximately one-half of the needles are still on the branches and are red. OR all the needles are on the branches, but they are green. Live fuels are not expected to influence fire behavior.	13
☐ Same as above, EXCEPT all the needles are attached and are red.	4

Figure 4.46 This key will aid in selecting the right fire behavior fuel model.

you started. You should take care in drawing the various lines or your predictions will not be accurate.

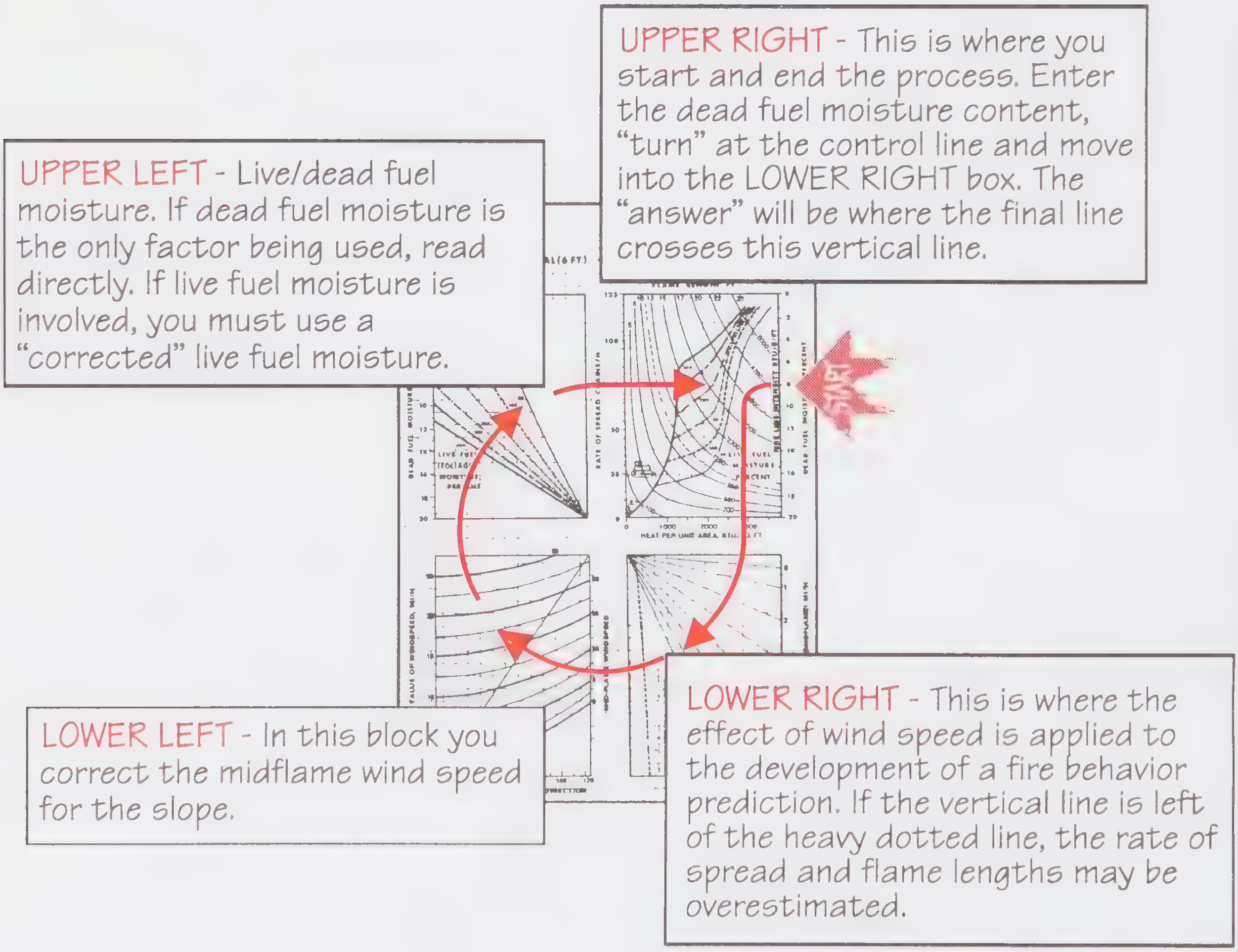
Using a nomogram is a lot easier than it looks.

Use of Nomograms

There are several steps to developing a meaningful fire behavior prediction. It is important that you use the proper nomogram and weather readings from the fire ground. The best way to show how to use a nomogram is to take a simple example and work through the nine major steps of fire prediction.

Here is the situation. You have arrived at a small grass fire that is moving from a road up a slope toward a subdivision. You

PARTS OF A NOMOGRAM



UPPER RIGHT - This is where you start and end the process. Enter the dead fuel moisture content, "turn" at the control line and move into the LOWER RIGHT box. The "answer" will be where the final line crosses this vertical line.

UPPER LEFT - Live/dead fuel moisture. If dead fuel moisture is the only factor being used, read directly. If live fuel moisture is involved, you must use a "corrected" live fuel moisture.

LOWER LEFT - In this block you correct the midflame wind speed for the slope.

LOWER RIGHT - This is where the effect of wind speed is applied to the development of a fire behavior prediction. If the vertical line is left of the heavy dotted line, the rate of spread and flame lengths may be overestimated.

Figure 4.47 The four parts of a nomogram.

need to develop your plan, and you want to know the rate of spread and flame length. Note: for this first example, let's assume that we are dealing with mostly dead fuels. After we work through the entire process, we'll show you how to adjust for live fuel moistures.

Step 1 Plot the fire on a map and record the weather

You have plotted the fire on a topographic map and recorded the weather. The information is as follows:

Date: **August 10**
Time: **1210 hours**
Fuel: **Short grass**
Aspect: **South**
Slope: **40 percent**
Wind: **South at 4 miles per hour**
Temperature: **85°**
Relative Humidity: **23 percent**
Shade: **None**
Elevation: **1200 feet**

Use the actual midflame wind speed if at all possible. If you cannot determine the actual midflame wind speed, you will need to approximate it using the Wind Speed Adjustment Table (Figure 4.48). Use the latest forecast (20-foot) winds, and multiply them by the appropriate adjustment factor. For example, let's say that we didn't know our midflame wind speed was 4 mph, but the latest weather forecast reported winds of 10 mph. The fire is in unsheltered logging slash fuels (Fire Behavior Fuel Model 11). If we multiply 10 mph by the adjustment factor 0.4, we come up with an approximate midflame wind speed of 4 mph.

Use actual midflame wind speed if you can.

Step 2 - Determine the fine dead fuel moisture content

Dead fuel moisture is an important factor in fire behavior predictions. Since you normally do not have the equipment and the time to determine the dead fuel moisture scientifically, you will have to use information at hand, namely the relative humidity. You

WIND ADJUSTMENT TABLE

Find the appropriate adjustment factor, and multiply it by the 20-foot wind speed.That will give you an approximation of the midflame wind speed, which you can use to predict fire behavior.

Fuel exposure	Fuel model		Adjustment factor
Unsheltered Fuels			
Fuel exposed directly to the wind—no overstory or sparse overstory; fuel beneath timber that has lost its foliage; fuel beneath timber near clearings or clearcuts; fuel on high ridges where trees offer little shelter from wind.	4		0.6
	13		0.5
	1, 3, 5, 6, 11, 12 (2,7)[1] (8,9, 10)[2]		0.4
Partially Sheltered Fuels			
Fuel beneath patchy timber where it is not well sheltered; fuel beneath standing timber at midslope or higher on a mountain with wind blowing directly at the slope.	All fuel models		0.3
Fully Sheltered Fuels			
Fuel sheltered beneath standing timber on flat or gentle slope or near base of mountain with steep slopes.	All Fuel Models	*Open Stands*	0.2
		Dense Stands	0.1

[1] Fuels usually partially sheltered. [2] Fuels usually fully sheltered.

Figure 4.48 Wind adjustment table. Multiply the forecast wind by the adjustment factor.

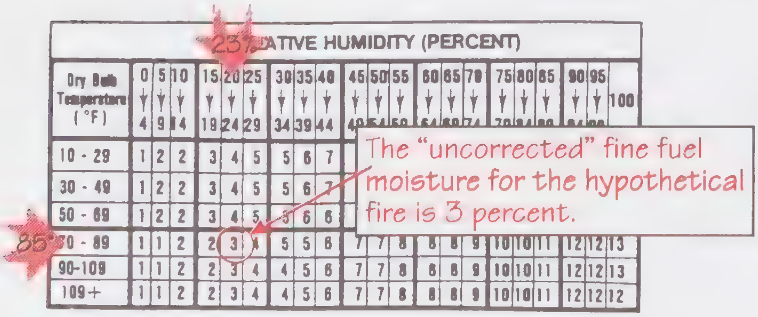
You can estimate the midflame windspeed by "adjusting" the 20-foot wind speed.

can get a relatively accurate fine dead fuel moisture content by using the following charts (Figure 4.49). The day-time readings will need to be "corrected" to account for slope, aspect, elevation, and time of day and year. The night-time corrections are less complicated, since there is no solar radiation at night. The appropriate correction tables for daytime and night-time are illustrated in Figures 4.50 and 4.51 respectively.

Once again, let's work through this process using our hypothetical fire. We know that the relative humidity is 23%, and the dry bulb temperature is 85°. By looking at the appropriate row and column on the fine fuel moisture table (Figure 4.49), we find that the "uncorrected" fine fuel moisture is 3%.

Now go to the day-time correction tables (Figure 4.50). Once you line up the appropriate row and col-

FINE FUEL MOISTURE TABLE



[illegible]ATIVE HUMIDITY (PERCENT)

Dry Bulb Temperature (°F)	0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75–79	80–84	85–[illegible]	90–[illegible]	95–[illegible]	100
10 - 29	1	2	2	3	4	5	5	6	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
30 - 49	1	2	2	3	4	5	5	6	7	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50 - 69	1	2	2	3	4	5	5	6	6	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]0 - 89	1	1	2	2	3	4	5	5	6	7	7	8	8	8	9	10	10	11	12	12	13
90-109	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	13
109+	1	1	2	2	3	4	4	5	6	7	7	8	8	8	9	10	10	11	12	12	12

The "uncorrected" fine fuel moisture for the hypothetical fire is 3 percent.

Figure 4.49. Fine fuel moisture tables. You can determine the "uncorrected" fuel moisture content by using the relative humidity and dry bulb temperature.

umn, you find that the correction factor for this scenario is 1%. Add that to the uncorrected fuel moisture of 3%, and your corrected fine fuel moisture content will be 4%.

If you were trying to predict the behavior at ten minutes past midnight instead of ten minutes past noon, you would use the night-time correction table instead (Figure 4.51). A southern slope at 1200 feet elevation would give you a correction factor of 2. Therefore, your corrected fine fuel moisture content would be 5%.

Fine fuel moistures can be calculated if you know the temperature, relative humidity, time of day, date, elevation, slope, and aspect.

FINE FUEL MOISTURE TABLE
(Night-time 2000 - 0759 hours)

	RELATIVE HUMIDITY (PERCENT)																				
Dry Bulb Temperature (°F)	0 ↓ 4	5 ↓ 9	10 ↓ 14	15 ↓ 19	20 ↓ 24	25 ↓ 29	30 ↓ 34	35 ↓ 39	40 ↓ 44	45 ↓ 49	50 ↓ 54	55 ↓ 59	60 ↓ 64	65 ↓ 69	70 ↓ 74	75 ↓ 79	80 ↓ 84	85 ↓ 89	90 ↓ 94	95 ↓ 99	100
10 - 29	1	2	4	5	5	6	7	8	9	10	11	12	12	14	15	17	19	22	25	25+	25+
30 - 49	1	2	3	4	5	6	7	8	9	9	11	11	12	13	14	16	18	21	24	25+	25+
50 - 69	1	2	3	4	5	6	6	8	8	9	10	11	11	12	14	16	17	20	23	25+	25+
70 - 89	1	2	3	4	4	5	6	7	8	9	10	10	11	12	13	15	17	20	23	25+	25+
90 - 109	1	2	3	3	4	5	6	7	8	9	9	10	10	11	13	14	16	19	22	25	25+
109+	1	2	2	3	4	5	6	6	8	8	9	9	10	11	12	14	16	19	21	24	25+

CORRECTION TABLE

	2000 ➤			2200 ➤			0000 ➤			0200 ➤			0400 ➤			0600 ➤		
	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N+E	9	1	1	13	1	2	16	2	2	17	1	1	18	1	1	16	2	1
S+W	9	0	1	14	0	1	16	0	2	17	0	1	18	0	0	9	0	1

A = 1000' - 2000' above site
L = ±1000' of site location
B = 1000' - 2000' below site

Figure 4.50. Dead fuel moisture content correction tables (Day-time). The number developed by using these tables should be added to the "uncorrected" fine fuel moisture content.

Step 3 - Determine the effective midflame wind speed

In order to determine the effective midflame wind speed, we need to now turn to the lower left quadrant of the appropriate nomogram for Fire Behavior Fuel Model 1 with a low wind speed. Across the bottom of this chart, you will find numbers representing the slope percentage. Since our scenario involves a 40% slope, you would draw a vertical line up from the 40% mark.

Along both sides of this chart, you will find numbers representing the wind speed. On the right is the actual (or calculated) midflame wind speed. On the left is the effective value of the wind speed based on the slope. Since this chart does not show a line for the 4 mph midflame wind speed in our hypothetical fire, you will have to draw an imaginary line to represent it. Start from the right hand side. Find the point where our 40% slope intersects a 4 mph midflame wind, then continue your line to the left until it hits the effective wind speed scale. In this case, the effective wind speed is 5 miles per hour.

FINE FUEL MOISTURE CORRECTION TABLES
(Daytime 0800 - 1959 hours)

MAY JUNE JULY

EXPOSED - LESS THAN 50% SHADING OF SURFACE FUELS

		0800➤			1000 ➤			1200 ➤			1400 ➤			1600 ➤			1800 ➤		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N	0-30%	2	3	4	1	1	1	0	0	1	0	0	1	1	1	1	2	3	4
	31%+	3	4	4	1	2	2	1	1	2	1	1	2	1	2	2	3	4	4
E	0-30%	2	2	3	1	1	1	0	0	1	0	0	1	1	1	2	3	4	4
	31%+	1	2	2	0	0	1	0	0	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	0-30%	2	3	3	1	1	1	0	0	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	31%+	2	3	3	1	1	2	0	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W	0-30%	2	3	4	1	1	2	0	0	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	31%+	4	5	6	2	3	4	1	1	2	0	0	1	0	0	1	1	2	2
SHADED - GREATER THAN OR EQUAL TO 50% SHADING OF SURFACE FUELS																			
N	0%+	4	5	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5
E	0%+	4	4	5	3	4	5	3	3	4	3	4	4	3	4	5	4	5	6
S	0%+	4	4	5	3	4	5	3	3	4	3	3	4	3	4	5	4	5	5
W	0%+	4	5	6	3	4	5	3	3	4	3	3	4	3	4	5	4	4	5

A = 1000' - 2000' above site
L = ±1000' of site location
B = 1000' - 2000' below site

FEBRUARY MARCH APRIL
AUGUST SEPTEMBER OCTOBER

EXPOSED - LESS THAN [illegible]DING OF SURFACE FUELS

		0800 ➤			1000 ➤			1200 ➤			1400 ➤			1600 ➤			1800 ➤		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N	0-30%	3	4	5	1	2	3	1	1	2	1	1	2	1	2	3	3	4	5
	31%+	3	4	5	3	3	4	2	3	4	2	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	0-30%	3	4	5	1	2	3	1	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	31%+	3	3	4	1	1	1	1	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	0-30%	3	4	5	1	2	2	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	31%+	3	4	5	1	2	2	0	1	1	0	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
W	0-30%	3	4	5	1	2	3	1	1	1	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	31%+	4	5	6	3	4	5	1	2	3	1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
SHADED - GREATER THAN OR EQUAL TO 50% SH[illegible]																			
N	0%+	4	5	6	4	5	5	3	4	5	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
E	0%+	4	5	6	3	4	5	3	4	5	3	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
S	0%+	4	5	6	3	4	5	3	4	5	3	4	5	3	4	5	4	5	6
W	0%+	4	5	6	4	5	6	3	4	5	3	4	5	3	4	5	4	5	6

If you wanted to develop a predicted fine fuel moisture for a site that was on a south facing slope over 31%, at 1300 hours, about 1500 feet below your reference location in August, the correction factor you would use is 1%.

NOVEMBER DECEMBER JANUARY

EXPOSED - LESS THAN 50% SHADING OF SURFACE FUELS

		0800 ➤			1000 ➤			1200 ➤			1400 ➤			1600 ➤			1800 ➤		
		B	L	A	B	L	A	B	L	A	B	L	A	B	L	A	B	L	A
N	0-30%	4	5	6	3	4	5	2	3	4	2	3	4	3	4	5	4	5	6
	31%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
E	0-30%	4	5	6	3	4	4	2	3	3	2	3	3	3	4	5	4	5	6
	31%+	4	5	6	2	3	4	2	2	3	3	4	4	4	5	6	4	5	6
S	0-30%	4	5	6	3	4	5	2	3	3	2	2	3	3	4	4	4	5	6
	31%+	4	5	6	2	3	3	1	1	2	1	1	2	2	3	3	4	5	6
W	0-30%	4	5	6	3	4	5	2	3	3	2	3	3	3	4	4	4	5	6
	31%+	4	5	6	4	5	6	3	4	4	2	2	3	2	3	4	4	5	6
SHADED - GREATER THAN OR EQUAL TO 50% SHADING OF SURFACE FUELS																			
N	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
E	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
S	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6
W	0%+	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6	4	5	6

Figure 4.51. Dead fuel moisture content correction tables (Nighttime). The number developed by using these tables should be added to the "uncorrected" fine fuel moisture content.

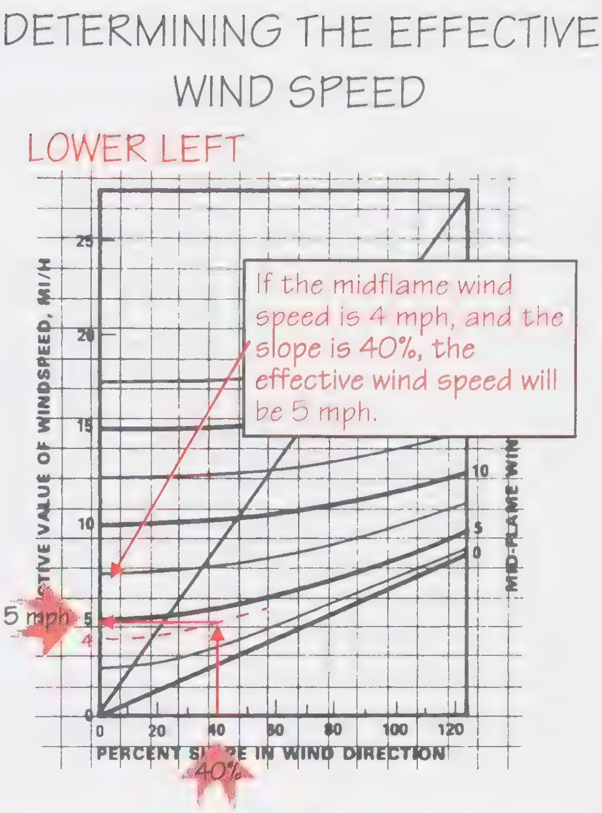
Step 4 - Start plotting the fire behavior prediction

Start plotting the fire behavior prediction in the upper right quadrant (Figure 4.53). Locate the dead fuel moisture content along the right side of the chart. In this case, our corrected fine fuel moisture content is 4%. Draw a line to the left until it intersects the S-shaped line.

Step 5 - Plot the line into the effective wind speed quadrant (lower right)

Now plot a line into the lower right quadrant. This will bring the effective wind speed into your prediction. Remember to plot the *effective* wind speed, not the *actual* wind speed. The effective wind speed we calculated in Step 3 is 5 mph.

Notice that there is one dashed line in this quadrant. This is the wind limit line. It represents the limiting wind speed at which point a faster wind does not necessarily cause faster rates of spread.



If the midflame wind speed is 4 mph, and the slope is 40%, the effective wind speed will be 5 mph.

Figure 4.52 You use the lower left quadrant to determine the effective midflame wind speed.

Step 6 - Plot the line into the lower left quadrant

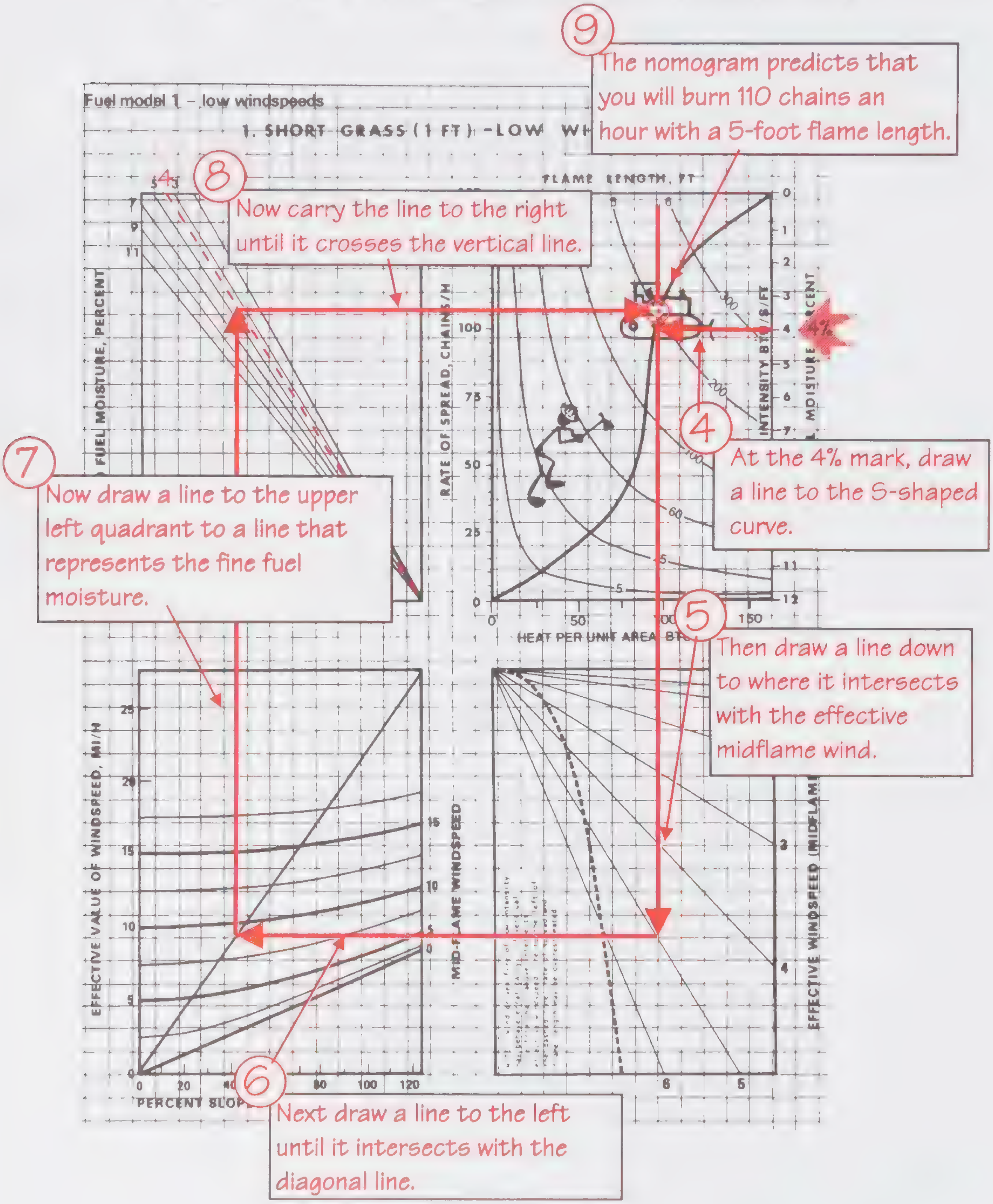
You already used this quadrant to determine the effective wind speed. At this point, the sole purpose for this quadrant is to redirect or turn your plot line into the upper quadrant. Plot your line until it intersects the diagonal line that goes across this quadrant.

Step 7 - Plot the line into the upper left quadrant

Now draw a line up into the upper left quadrant until it intersects a line that represents the fine fuel moisture content. In this case, it is 4%. Once again, you will need to draw an imaginary line since the chart only shows 3% and 5%.

This step in the process is designed to factor in something called "heat sink." Before the fuel can reach its ignition temperature, some heat must be expended to drive off the moisture. This reduces the amount of heat energy that goes into sustaining the fire. (Factoring in this heat energy reduction is analogous to factoring in friction loss when providing a water supply.)

PLOTTING A FIRE BEHAVIOR PREDICTION



④ At the 4% mark, draw a line to the S-shaped curve.

⑤ Then draw a line down to where it intersects with the effective midflame wind.

⑥ Next draw a line to the left until it intersects with the diagonal line.

⑦ Now draw a line to the upper left quadrant to a line that represents the fine fuel moisture.

⑧ Now carry the line to the right until it crosses the vertical line.

⑨ The nomogram predicts that you will burn 110 chains an hour with a 5-foot flame length.

Figure 4.53 Plotting a fire behavior prediction. Follow the various steps using this drawing. Keep lines straight and aligned with the grid.

Step 8 - Plot the line back into the upper right quadrant

Draw your final line back into the upper right quadrant until it intersects with the vertical line that you drew in Step 5.

Step 9 - Finalize your fire behavior prediction

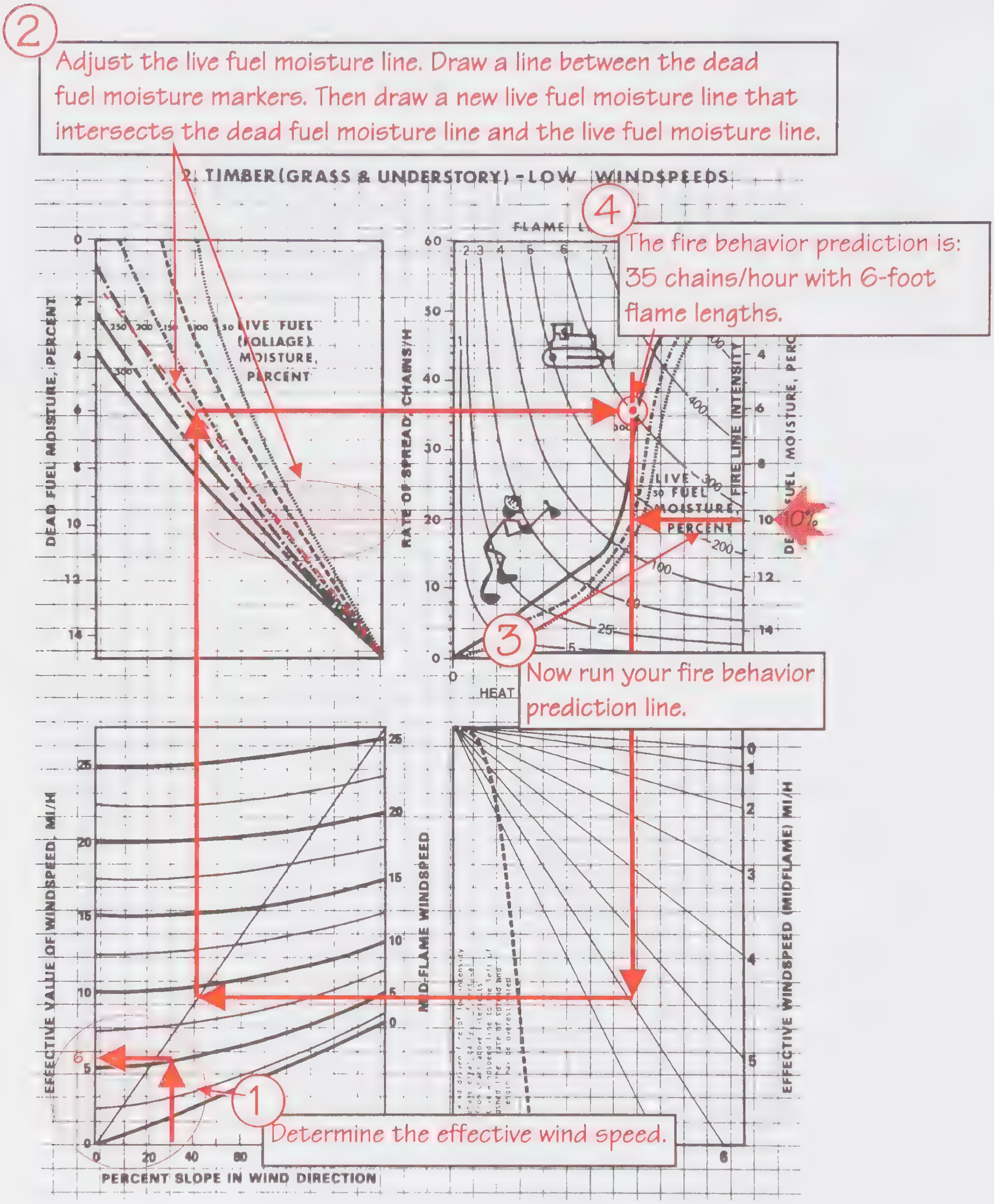
The intersection of these two lines provides the "answer" to your prediction. These two lines intersect an arc that represents a flame length of 5 feet (see upper scale along this quadrant) and 200 BTUs per square feet (see scale on right side of quadrant). Follow your final line back to the left side of this quadrant, where you can see that the fire is predicted to spread at a rate of 110 chains per hour. Along the bottom of this quadrant, you can see that the fuel will generate just under 100 BTUs of heat energy per unit area. Remember, we said earlier in the chapter that if the flame length is over four feet, it will pretty much eliminate hand tools as a method of control. You may still be able to use hand tools on the flanks, where there is less risk of getting caught in the path of the fire. However, you must continually be alert for changes in wind direction and fire behavior.

A fire prediction is just an estimate of what the fire may do. Don't base your entire plan on this estimation.

If you replot the chart with different factors, you get some significant changes in the prediction. Remember that every time there is a change in condition (e.g., wind speed, slope, humidity), you will have to rerun the prediction.

If live fuel moistures are involved, and several of the nomograms require this input, the setup for the plot is done a little differently (Figure 4.54). You still have to determine the effective wind speed. Do this in the same way (Figure 4.52). Now you must adjust the live fuel moisture line in the upper left quadrant. In this example we use a live fuel moisture of 150%. To adjust this line, start by drawing a line from the dead fuel moisture scale on the outside edges of both the upper right and left quadrants. In this example we will use a dead fuel moisture of 10%. Draw a line between the 10% dead fuel moisture scales on the two top quadrants. Mark in the upper left quadrant where this line intersects the 150% line. Then draw a "corrected" 150% live fuel moisture line from the intersection of all the lines in the lower right-hand corner through this mark.

PLOTTING A FIRE BEHAVIOR PREDICTION WHEN LIVE FUEL MOISTURES ARE A FACTOR



② Adjust the live fuel moisture line. Draw a line between the dead fuel moisture markers. Then draw a new live fuel moisture line that intersects the dead fuel moisture line and the live fuel moisture line.

④ The fire behavior prediction is: 35 chains/hour with 6-foot flame lengths.

③ Now run your fire behavior prediction line.

① Determine the effective wind speed.

Figure 4.54 Plotting a fire behavior prediction on some of the nomograms requires the input of an estimate of the live fuel moisture.

Now draw the five lines that make the fire prediction plot. This example says that the dead fuel moisture is 10 percent, the effective wind speed is 6 miles per hour, and the live fuel moisture is 150 percent. The resulting plot predicts that the fire will have a rate of spread of 35 chains per hour and burn with a 6-foot flame length.

There are 26 nomograms; they can be purchased from the federal fire cache in Boise, Idaho. Use them, but remember that they have limitations (Figure 4.55). They are for free burning fires where the fuels, weather, and slope are all uniform. Remember, the prediction you make by using a nomogram provides a good ***estimate of fire behavior***; it is not fact.

Figure 4.55 This firefighter is having a real problem with his nomogram. Nomograms are easier to use than to explain!

Determining Slope

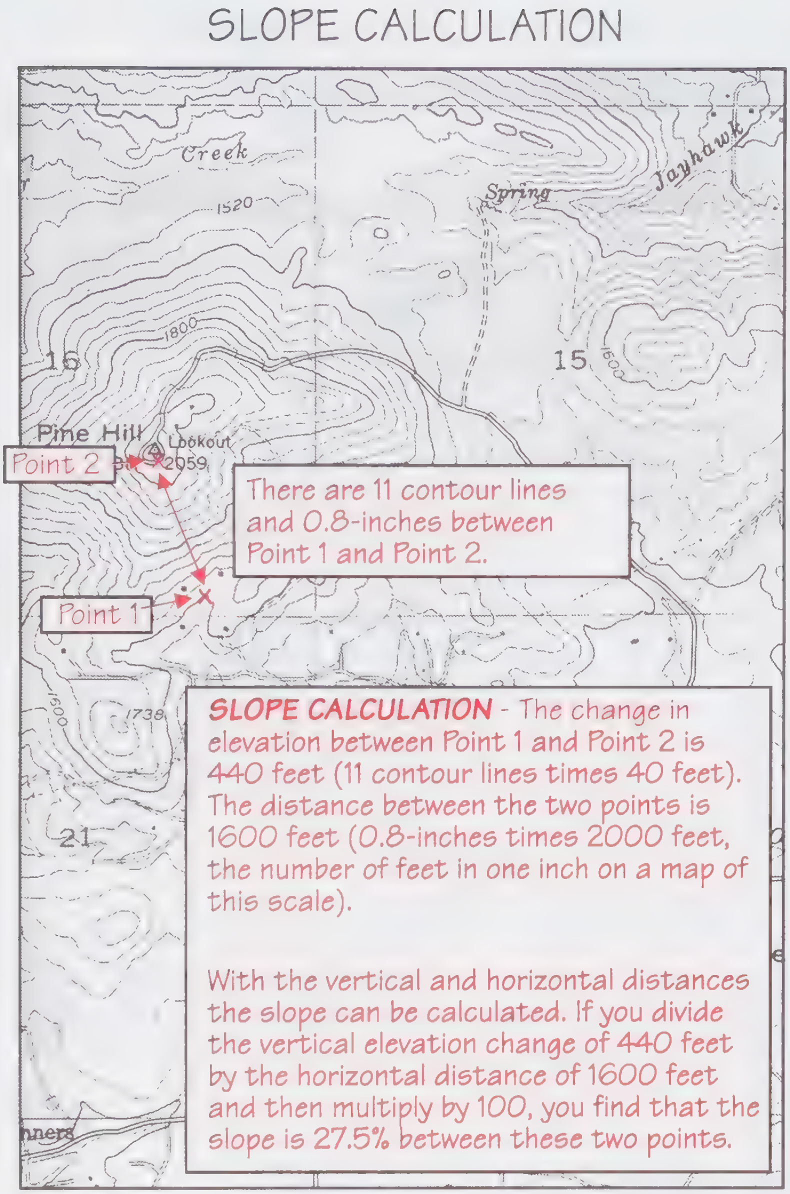
Slope is the change of elevation between two points divided by the horizontal difference between them. If you multiply this ratio by 100, it gives you the slope as a percentage.

Slope (%) = (Elevation difference ÷ Distance) x 100

It is easy to determine the slope if you have a contour map.

If, for example, the elevation difference between your fire and the ridge line is 1200 feet, and the distance between the two points is 2400 feet, the slope would be 50%. (1200 divided by 2400 equals 0.5. That multiplied by 100 equals 50 or 50%).

You will frequently have to determine elevation and distance by using a contour map (Figure 4.56). The contour lines represent changes in elevation. The contour interval in this case is 40 feet, meaning that the elevation increases by forty feet between each set of lines. Notice that there are 11 contour lines between the fire and the ridge line. That means that the difference in elevation is 440 feet. (11 contour lines multiplied by 40 feet equals a total of 440 feet.)


SLOPE CALCULATION

There are 11 contour lines and 0.8-inches between Point 1 and Point 2.

SLOPE CALCULATION - The change in elevation between Point 1 and Point 2 is 440 feet (11 contour lines times 40 feet). The distance between the two points is 1600 feet (0.8-inches times 2000 feet, the number of feet in one inch on a map of this scale).

With the vertical and horizontal distances the slope can be calculated. If you divide the vertical elevation change of 440 feet by the horizontal distance of 1600 feet and then multiply by 100, you find that the slope is 27.5% between these two points.

Figure 4.56 It is easy to caculate the slope between two points using a contour map.

You can determine the actual distance between the two points in two ways. The method you are probably most familiar with is to measure the distance on the map with a ruler and compare that to a scale usually found at the bottom of the map. This distance between these two points on the map is 0.8-inch. One inch on this map represents a distance of 2000 feet. Multiply 2000 feet by 0.8, and you will see that the actual distance between these two points is about 1600 feet.

The second method involves using a map scale conversion chart (Figure 4.57) to calculate the distance. If you had the complete map page in front of you, you would see a notation that this map is part of a 7.5-minute quadrangle map which uses a scale of 1:24,000. As you read across this line, you can see that 1 inch on the map represents 24,000 inches or 2.64 miles or 0.033 chains or 2,000 feet. This comes in handy when you need to know distances in different scales. Once again, the distance between the fire and the ridge line when measured on the map is 0.8 inches. If you multiply that by 2000, you get a distance of 1600 feet.

Now that we know the elevation difference and the distance between these two points, we can calculate the slope. The elevation distance of 440 feet, divided by the distance of 1600 feet,

MAP SCALE CONVERSION CHART

Map Scale	Representative Fraction	Map (inch/mile)	Map (inch/chain)	Feet/map inch
1:253,440	253.44	0.25	0.0031	21120
1:126,720	126.72	0.5	0.0063	10560
1:63,360	63.36	1	0.0125	5280
1:62,500	62.5	1.01	0.027	5280
1:31,680	31.68	2	0.025	2640
1:24,000	24	2.64	0.033	2000
1:21,120	21.12	3	0.38	1760
1:15,840	15.84	4	0.05	1320
1:7,920	7.92	8	0.1	660

Figure 4.57 A Map Scale Conversion Chart will aid you in calculating map distance when you want to plot a nomogram fire behavior prediction, or when trying to determine ground distance needed for a slope calculation.

gives us a ratio of 0.275. If we multiply that by 100, we find that we have a slope of 27.5%. For your fire behavior prediction, you can round it off to 30%.

Cross-Slope Fire Spread

There will be times when the wind is not aligned with the slope. In these cases, you will have to develop two predictions; one that takes into account the slope and no wind, and one that takes into account the wind and no slope. These two predictions are then combined to give the proper projection.

To combine these two predictions, you will use a procedure you learned in high school geometry class: vectoring. A vector is the combination of two different "forces" into one result (Figure 4.58).

To demonstrate how you deal with a cross-slope wind/slope situation, let's use an example: A fire has spread from a structure

A vector is the combination of two different forces; in this case wind and slope.

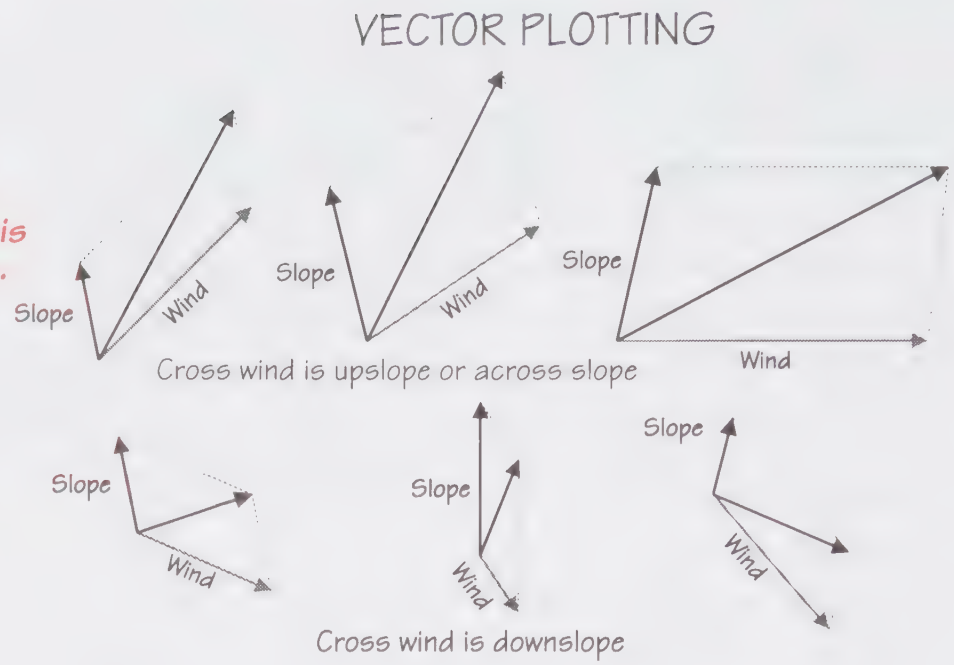

VECTOR PLOTTING
Slope
Wind
Slope
Wind
Slope
Wind
Cross wind is upslope or across slope
Slope
Wind
Slope
Wind
Slope
Wind
Cross wind is downslope

Figure 4.58 Vectoring is the combining of two different "forces" into one result. Use this method to combine the different impacts of wind and slope on fire spread.

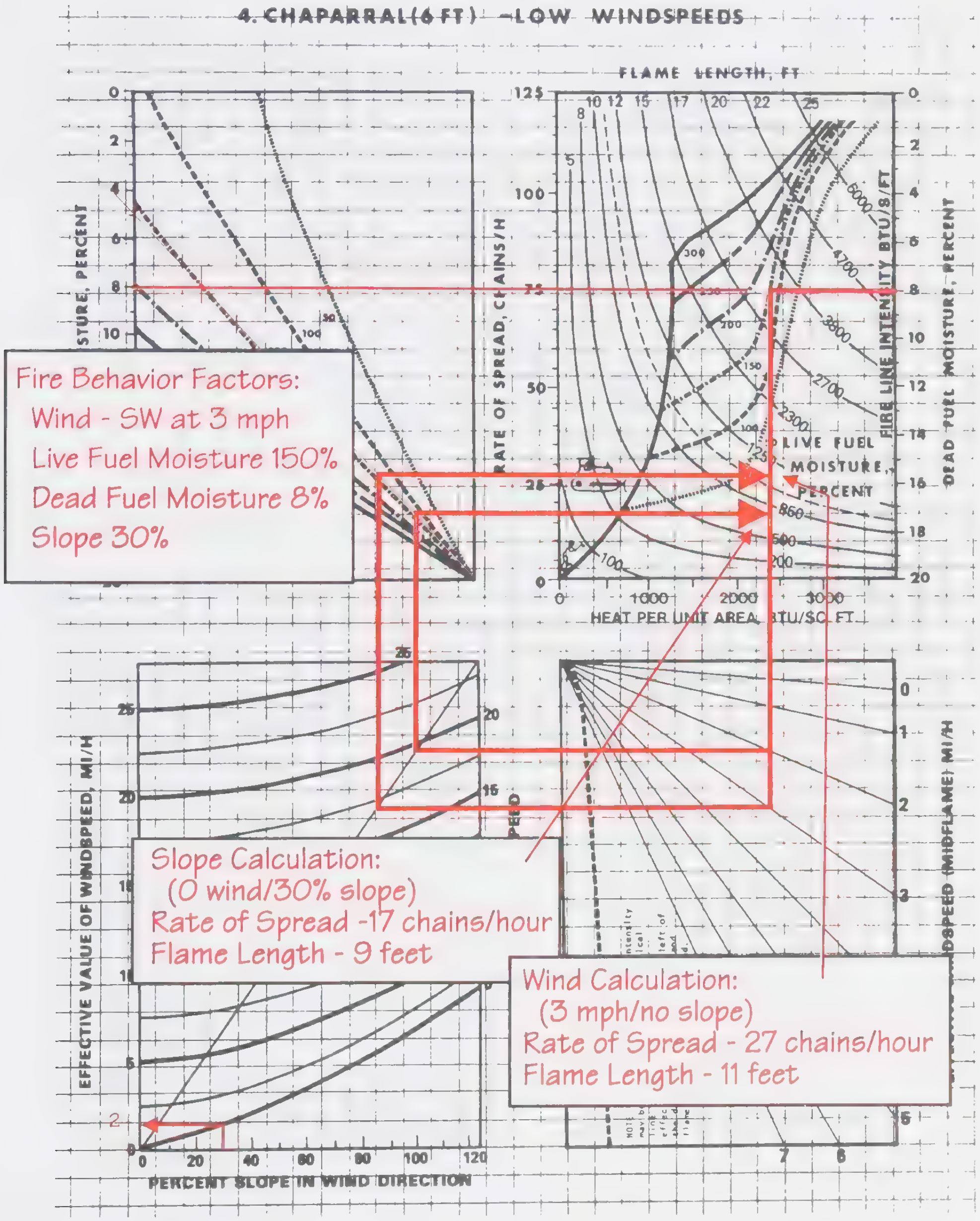
fire on the south slope of Pine Hill. By the time the initial attack force arrives, the fire is just starting to move up the slope. The fire behavior factors are as follows:

Wind - **Southwest at 3 miles per hour**
Fuel Model - **4. Chaparral**
Live Fuel Moisture - **150%**
Dead Fine Fuel Moisture - **8%**
Slope - **30%**

The effects of slope and wind are calculated and plotted separately. The vector is then the rate of spread.

Using the nomogram for Fuel Model 4 for chaparral (low wind speed), plot two fire behavior predictions (Figure 4,59). The first plot will be for a 30% slope with zero wind. Be sure to develop an "effective" wind speed for this slope (2 miles per hour—if you forgot how to do this, refer back to Step 3 on page 191). This plot indicates that the slope effect on the rate of spread will be 17 chains/hour with a flame length of 9 feet. Now plot the wind effect on the rate of spread. Do not correct this wind for slope. This plot shows that the wind will create a rate of spread of 27 chains/hour with a flame length of 11 feet.

CROSS-SLOPE FIRE BEHAVIOR CACULATIONS



Fire Behavior Factors:
Wind - SW at 3 mph
Live Fuel Moisture 150%
Dead Fuel Moisture 8%
Slope 30%

Slope Calculation:
(0 wind/30% slope)
Rate of Spread -17 chains/hour
Flame Length - 9 feet

Wind Calculation:
(3 mph/no slope)
Rate of Spread - 27 chains/hour
Flame Length - 11 feet

Figure 4.59 Nomogram calculations for the fire on Pine Hill.

Plotting of the Fire Behavior Prediction

You must now convert these two rates of spread identified by the nomogram to map distance, so that you can accurately plot the vectors. One way to do this is to convert the rate of spread distance to feet (one chain equals 66 feet). Then use the map scale conversion chart (Figure 4.57) to divide the number of feet by the number of feet per map inch. You can also multiply the number of chains by the factor listed in the column "map inch/chain."

Example: You need to plot 17 chains on your map.
17 chains x 66 feet = 1122 feet
then
Divide 1122 by 2000, the number of feet in 1 inch of map
(1122 ÷ 2000 = 0.56 inch)
OR
Multiply 17 chains by 0.033 to convert to map distance in inches (17 x 0.033 = 0.56 inch)

Now that you know the map distance, plot it on the map (Figure 4.60). This distance represents how far the fire will burn in one hour if the rate of spread is 17 chains per hour. Remember, this is based on slope only. Now we need to plot the wind effect.

The second line shows how far the fire will burn in one hour if the rate of spread is 27 chains per hour and slope is not a factor. Remember, if you are plotting a cross-wind, draw your line in the proper direction.

The vector line represents a kind of compromise between the two factors of slope and wind. If you measure the difference between where the line starts (the current location of your fire) and where it ends, this tells you that the combined influence of slope and wind will cause the fire to burn 40 chains in the first hour. The length of the line is 1.3 inches. Looking at the Map Scale Conversion Chart we see that one chain equals 0.033 inches. That means we need to divide 1.3 inches by a factor of 0.033. The result is approximately 40 chains.

Estimating Acreage and Length of Perimeter

Once you have determined the rate of spread, you can make some estimates regarding the area (acreage) the fire will burn and the length of its perimeter. Specific charts have been developed to assist you with this task (Figure 4.61). This, in turn, will help in estimating how many firefighting resources you are going to need and when you will need them.

Since fires burn in predictable patterns, charts can be produced that will aid in estimating area and perimeter.

CROSS-SLOPE FIRE BEHAVIOR SPREAD

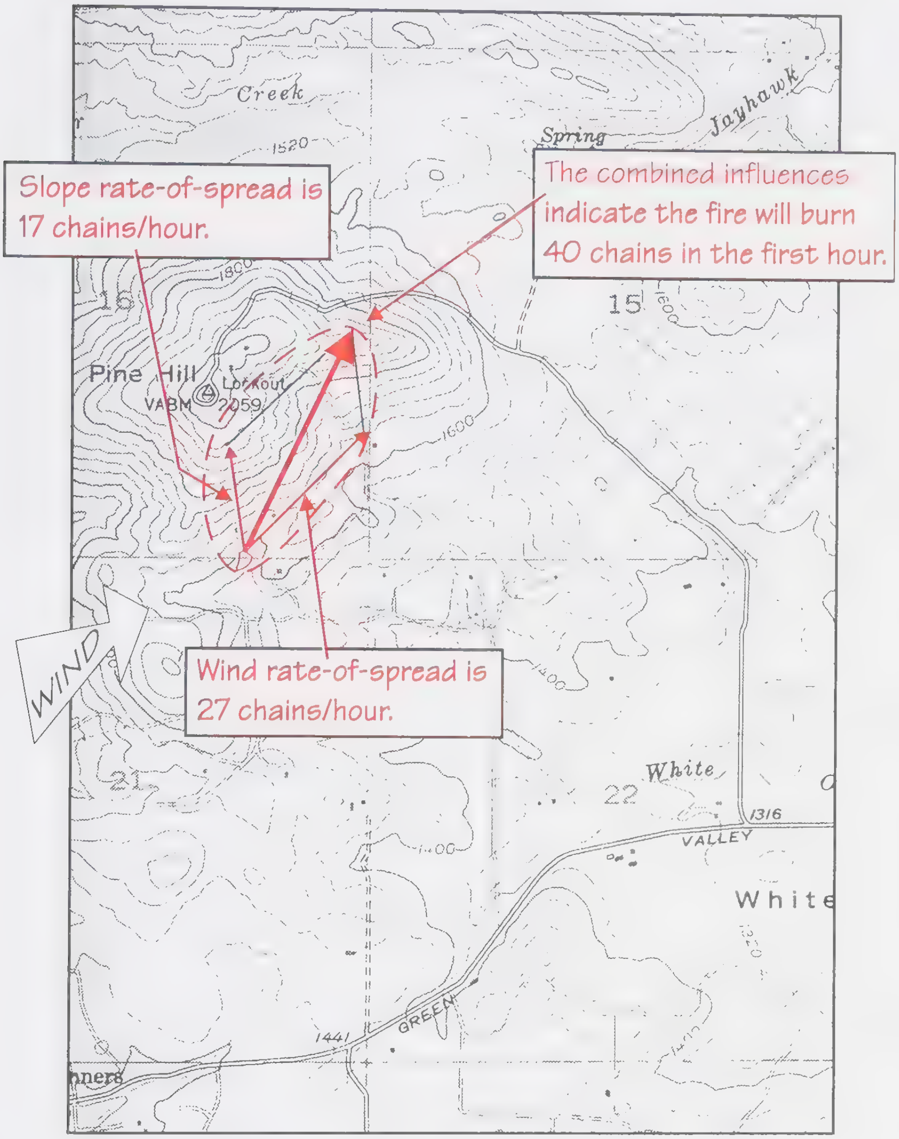
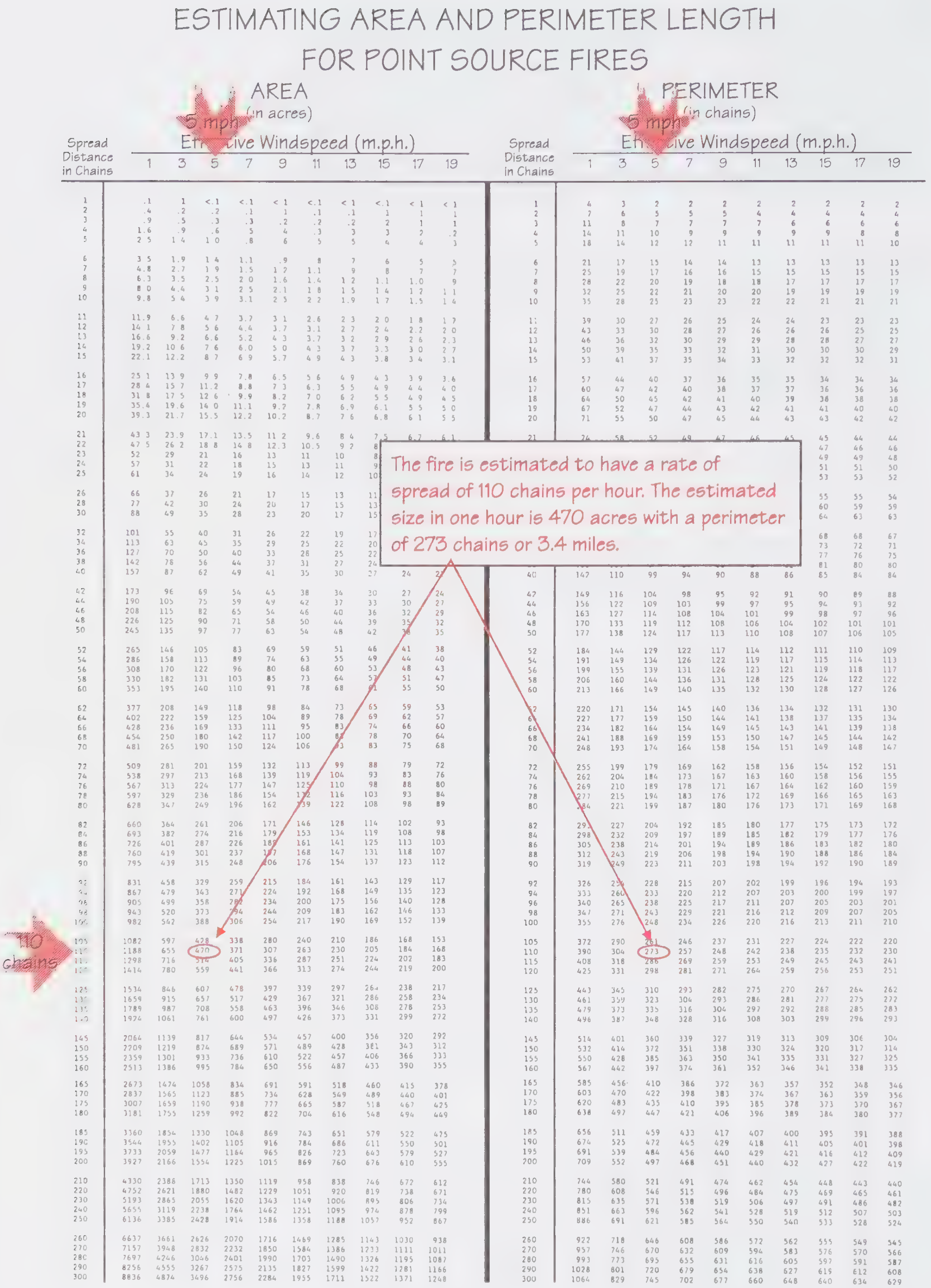

Creek
Spring
Jayhawk
1520
Slope rate-of-spread is 17 chains/hour.
The combined influences indicate the fire will burn 40 chains in the first hour.
1800
16
15
1600
Pine Hill
Lookout
VABM
2059
1600
WIND
Wind rate-of-spread is 27 chains/hour.
1400
21
White
22
1316
VALLEY
1400
White
1441
GREEN
nners

Figure 4.60 Using a nomogram you can calculate the effect of slope and wind. The rate-of-spread can then be plotted. The plot shows that the fire will burn 40 chains in the first hour.

In the example we were using above, we predicted the fire would burn at a rate of 40 chains per hour. Our wind speed was 3 miles per hour. By using this chart, we see that a spread rate of 40 chains per hour with a 3 mph wind would consume 87 acres in the first hour. The perimeter of the fire would be roughly 110 chains or 1.375 miles. Remember, we are talking about the length of the


5 mph
5 mph
110 chains

ESTIMATING AREA AND PERIMETER LENGTH FOR POINT SOURCE FIRES

The fire is estimated to have a rate of spread of 110 chains per hour. The estimated size in one hour is 470 acres with a perimeter of 273 chains or 3.4 miles.

AREA

(in acres)

Effective Windspeed (m.p.h.)

Spread Distance in Chains	1	3	5	7	9	11	13	15	17	19
1	.1	1	<.1	<.1	< 1	<.1	< 1	<.1	< 1	< 1
2	.4	.2	.2	.1	1	.1	.1	1	1	1
3	.9	.5	.3	.3	.2	.2	.2	2	1	1
4	1.6	.9	.6	5	4	.3	3	3	2	.2
5	2.5	1.4	1.0	.8	6	5	5	4	4	3
6	3.5	1.9	1.4	1.1	.9	8	7	6	5	5
7	4.8	2.7	1.9	1.5	1.2	1.1	9	8	7	7
8	6.3	3.5	2.5	2.0	1.6	1.4	1.2	1.1	1.0	9
9	8.0	4.4	3.1	2.5	2.1	1.8	1.5	1.4	1.2	1.1
10	9.8	5.4	3.9	3.1	2.5	2.2	1.9	1.7	1.5	1.4
11	11.9	6.6	4.7	3.7	3.1	2.6	2.3	2.0	1.8	1.7
12	14.1	7.8	5.6	4.4	3.7	3.1	2.7	2.4	2.2	2.0
13	16.6	9.2	6.6	5.2	4.3	3.7	3.2	2.9	2.6	2.3
14	19.2	10.6	7.6	6.0	5.0	4.3	3.7	3.3	3.0	2.7
15	22.1	12.2	8.7	6.9	5.7	4.9	4.3	3.8	3.4	3.1
16	25.1	13.9	9.9	7.8	6.5	5.6	4.9	4.3	3.9	3.6
17	28.4	15.7	11.2	8.8	7.3	6.3	5.5	4.9	4.4	4.0
18	31.8	17.5	12.6	9.9	8.2	7.0	6.2	5.5	4.9	4.5
19	35.4	19.6	14.0	11.1	9.2	7.8	6.9	6.1	5.5	5.0
20	39.3	21.7	15.5	12.2	10.2	8.7	7.6	6.8	6.1	5.5
21	43.3	23.9	17.1	13.5	11.2	9.6	8.4	7.5	6.7	6.1
22	47.5	26.2	18.8	14.8	12.3	10.5	9.2	[illegible]	[illegible]	[illegible]
23	52	29	21	16	13	11	10	8	[illegible]	[illegible]
24	57	31	22	18	15	13	11	9	[illegible]	[illegible]
25	61	34	24	19	16	14	12	10	[illegible]	[illegible]
26	66	37	26	21	17	15	13	11	[illegible]	[illegible]
28	77	42	30	24	20	17	15	13	[illegible]	[illegible]
30	88	49	35	28	23	20	17	15	[illegible]	[illegible]
32	101	55	40	31	26	22	19	17	[illegible]	[illegible]
34	113	63	45	35	29	25	22	20	[illegible]	[illegible]
36	127	70	50	40	33	28	25	22	[illegible]	[illegible]
38	142	78	56	44	37	31	27	24	[illegible]	[illegible]
40	157	87	62	49	41	35	30	27	24	[illegible]
42	173	96	69	54	45	38	34	30	27	24
44	190	105	75	59	49	42	37	33	30	27
46	208	115	82	65	54	46	40	36	32	29
48	226	125	90	71	58	50	44	39	35	32
50	245	135	97	77	63	54	48	42	38	35
52	265	146	105	83	69	59	51	46	41	38
54	286	158	113	89	74	63	55	49	44	40
56	308	170	122	96	80	68	60	53	48	43
58	330	182	131	103	85	73	64	57	51	47
60	353	195	140	110	91	78	68	61	55	50
62	377	208	149	118	98	84	73	65	59	53
64	402	222	159	125	104	89	78	69	62	57
66	428	236	169	133	111	95	83	74	66	60
68	454	250	180	142	117	100	88	78	70	64
70	481	265	190	150	124	106	93	83	75	68
72	509	281	201	159	132	113	99	88	79	72
74	538	297	213	168	139	119	104	93	83	76
76	567	313	224	177	147	125	110	98	88	80
78	597	329	236	186	154	132	116	103	93	84
80	628	347	249	196	162	139	122	108	98	89
82	660	364	261	206	171	146	128	114	102	93
84	693	382	274	216	179	153	134	119	108	98
86	726	401	287	226	188	161	141	125	113	103
88	760	419	301	237	197	168	147	131	118	107
90	795	439	315	248	206	176	154	137	123	112
92	831	458	329	259	215	184	161	143	129	117
94	867	479	343	271	224	192	168	149	135	123
96	905	499	358	282	234	200	175	156	140	128
98	943	520	373	294	244	209	183	162	146	133
100	982	542	388	306	254	217	190	169	152	139
105	1082	597	428	338	280	240	210	186	168	153
110	1188	655	470	371	307	263	230	205	184	168
115	1298	716	514	405	336	287	251	224	202	183
120	1414	780	559	441	366	313	274	244	219	200
125	1534	846	607	478	397	339	297	264	238	217
130	1659	915	657	517	429	367	321	286	258	234
135	1789	987	708	558	463	396	346	308	278	253
140	1924	1061	761	600	497	426	373	331	299	272
145	2064	1139	817	644	534	457	400	356	320	292
150	2209	1219	874	689	571	489	428	381	343	312
155	2359	1301	933	736	610	522	457	406	366	333
160	2513	1386	995	784	650	556	487	433	390	355
165	2673	1474	1058	834	691	591	518	460	415	378
170	2837	1565	1123	885	734	628	549	489	440	401
175	3007	1659	1190	938	777	665	587	518	467	425
180	3181	1755	1259	992	822	704	616	548	494	449
185	3360	1854	1330	1048	869	743	651	579	522	475
190	3544	1955	1402	1105	916	784	686	611	550	501
195	3733	2059	1477	1164	965	826	723	643	579	527
200	3927	2166	1554	1225	1015	869	760	676	610	555
210	4330	2388	1713	1350	1119	958	838	746	672	612
220	4752	2621	1880	1482	1229	1051	920	819	738	671
230	5193	2865	2055	1620	1343	1149	1006	895	806	734
240	5655	3119	2238	1764	1462	1251	1095	974	878	799
250	6136	3385	2428	1914	1586	1358	1188	1057	952	867
260	6637	3661	2626	2070	1716	1469	1285	1143	1030	938
270	7157	3948	2832	2232	1850	1584	1386	1233	1111	1011
280	7697	4246	3046	2401	1990	1703	1490	1326	1195	1087
290	8256	4555	3267	2575	2135	1827	1599	1422	1281	1166
300	8836	4874	3496	2756	2284	1955	1711	1522	1371	1248

PERIMETER

(in chains)

Effective Windspeed (m.p.h.)

Spread Distance in Chains	1	3	5	7	9	11	13	15	17	19
1	4	3	2	2	2	2	2	2	2	2
2	7	6	5	5	5	4	4	4	4	4
3	11	8	7	7	7	7	6	6	6	6
4	14	11	10	9	9	9	9	9	8	8
5	18	14	12	12	11	11	11	11	11	10
6	21	17	15	14	14	13	13	13	13	13
7	25	19	17	16	16	15	15	15	15	15
8	28	22	20	19	18	18	17	17	17	17
9	32	25	22	21	20	20	19	19	19	19
10	35	28	25	23	23	22	22	21	21	21
11	39	30	27	26	25	24	24	23	23	23
12	43	33	30	28	27	26	26	26	25	25
13	46	36	32	30	29	29	28	28	27	27
14	50	39	35	33	32	31	30	30	30	29
15	53	41	37	35	34	33	32	32	32	31
16	57	44	40	37	36	35	35	34	34	34
17	60	47	42	40	38	37	37	36	36	36
18	64	50	45	42	41	40	39	38	38	38
19	67	52	47	44	43	42	41	41	40	40
20	71	55	50	47	45	44	43	43	42	42
21	74	58	52	49	47	46	45	45	44	44
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	47	46	46
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	49	49	48
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	51	51	50
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	53	53	52
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	55	55	54
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	60	59	59
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	64	63	63
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	68	68	67
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	73	72	71
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	77	76	75
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	81	80	80
40	147	110	99	94	90	88	86	85	84	84
47	149	116	104	98	95	92	91	90	89	88
44	156	122	109	103	99	97	95	94	93	92
46	163	127	114	108	104	101	99	98	97	96
48	170	133	119	112	108	106	104	102	101	101
50	177	138	124	117	113	110	108	107	106	105
52	184	144	129	122	117	114	112	111	110	109
54	191	149	134	126	122	119	117	115	114	113
56	199	155	139	131	126	123	121	119	118	117
58	206	160	144	136	131	128	125	124	122	122
60	213	166	149	140	135	132	130	128	127	126
62	220	171	154	145	140	136	134	132	131	130
64	227	177	159	150	144	141	138	137	135	134
66	234	182	164	154	149	145	143	141	139	138
68	241	188	169	159	153	150	147	145	144	142
70	248	193	174	164	158	154	151	149	148	147
72	255	199	179	169	162	158	156	154	152	151
74	262	204	184	173	167	163	160	158	156	155
76	269	210	189	178	171	167	164	162	160	159
78	277	215	194	183	176	172	169	166	165	163
80	284	221	199	187	180	176	173	171	169	168
82	291	227	204	192	185	180	177	175	173	172
84	298	232	209	197	189	185	182	179	177	176
86	305	238	214	201	194	189	186	183	182	180
88	312	243	219	206	198	194	190	188	186	184
90	319	249	223	211	203	198	194	192	190	189
92	326	254	228	215	207	202	199	196	194	193
94	333	260	233	220	212	207	203	200	199	197
96	340	265	238	225	217	211	207	205	203	201
98	347	271	243	229	221	216	212	209	207	205
100	355	276	248	234	226	220	216	213	211	210
105	372	290	261	246	237	231	227	224	222	220
110	390	304	273	257	248	242	238	235	232	230
115	408	318	286	269	259	253	249	245	243	241
120	425	331	298	281	271	264	259	256	253	251
125	443	345	310	293	282	275	270	267	264	262
130	461	359	323	304	293	286	281	277	275	272
135	479	373	335	316	304	297	292	288	285	283
140	496	387	348	328	316	308	303	299	296	293
145	514	401	360	339	327	319	313	309	306	304
150	532	414	372	351	338	330	324	320	317	314
155	550	428	385	363	350	341	335	331	327	325
160	567	442	397	374	361	352	346	341	338	335
165	585	456	410	386	372	363	357	352	348	346
170	603	470	422	398	383	374	367	363	359	356
175	620	483	435	410	395	385	378	373	370	367
180	638	497	447	421	406	396	389	384	380	377
185	656	511	459	433	417	407	400	395	391	388
190	674	525	472	445	429	418	411	405	401	398
195	691	539	484	456	440	429	421	416	412	409
200	709	552	497	468	451	440	432	427	422	419
210	744	580	521	491	474	462	454	448	443	440
220	780	608	546	515	496	484	475	469	465	461
230	815	635	571	538	519	506	497	491	486	482
240	851	663	596	562	541	528	519	512	507	503
250	886	691	621	585	564	550	540	533	528	524
260	922	718	646	608	586	572	562	555	549	545
270	957	746	670	632	609	594	583	576	570	566
280	993	773	695	655	631	616	605	597	591	587
290	1028	801	720	679	654	638	627	619	612	608
300	1064	829	745	702	677	660	648	640	634	629

Figure 4.61 Once you have determined the rate of spread, use these tables to estimate the size and perimeter of the fire.

perimeter, not the distance the fire will travel. That was estimated at 40 chains. An elliptical shape is used to depict the fire area. Using an elliptical shape assumes that all factors (fuel, slope, etc.) will remain constant. The more variations in these factors, the less accurate this estimate will be.

Let's look at another example, where the fire is burning at a rate of 110 chains per hour with a 5 mph wind. This fire will consume 470 acres, with a perimeter length of 273 chains or 3.4 miles.

You have learned some of the basics of fire behavior prediction. The next chapter will dramatically underscore why it's so critical to respect fire behavior predictions and why you should increase your competency in this area.

Notes:

5

Extreme Fire Behavior

"Drought and adverse weather combined to set the stage for extreme fire behavior. Massive crowning, spotting, and fast spread characterized the fires, which trapped more than 200 firefighters. But, thanks to good crew leadership and the fire shelter, many deaths and serious injuries were prevented." Art Jukkala and Ted Putnam, Forest Fire Shelters Save Lives, NFES 6093.

In Chapter 4, fire behavior was discussed in two dimensions. In this chapter, we will discuss fire behavior in a third dimension—when the fire takes on a life of its own. Most fireline burn injuries or deaths are tied to extreme fire behavior. In too many cases, the investigation reports state that the "blowup" was unexpected. Should this be so, or can these events be predicted?

Extreme fire behavior is defined as periods of:

- Rapid rate-of-spread, when the fire may travel at rates close to 10 miles per hour.
- Intense burning, when canyons of brush or fuel literally explode.
- Considerable spotting; having a fire spot a mile is not uncommon.
- Crown fires, when the fire moves up into the crowns of the fuel, and burns rapidly and with considerable intensity.

Some or all of these events may occur on a fire simultaneously, or individually, at different times or in different locations. You must be able to predict and anticipate their occurrence.

In this chapter, you'll

- *Gain an appreciation for extreme fire behavior.*
- *Learn to recognize the various indicators of extreme fire behavior.*
- *Learn to analyze spotting potential.*
- *Learn what factors contribute to extreme fire behavior.*
- *Learn about wind-driven and plume-driven fires.*
- *Review the fire behavior and lessons learned from several major fires.*

Extreme Fire Behavior Indicators

There are indicators which can help you predict the possibility of extreme fire behavior. To ensure that you are tracking these indicators, you must take into consideration the seven factors that constitute the fire environment (Figure 5.1). These factors are:

- **Fuel Characteristics** - What is the fuel? How is it arranged? Is it compact? Is it loosely arranged?
- **Fuel Moisture** - This includes both dead and live fuel moistures.
- **Fuel Temperature** - Are the fuels shaded? Can you expect the fuels to warm in the next few hours, and thus change the fire behavior?
- **Terrain** - Is it steep? Will the fire be moving into better or worse terrain? Is the fire burning on a south-facing slope in the afternoon?
- **Wind** - What are the present and predicted midflame winds, local winds, and general winds?
- **Stability** - Is there an inversion layer, and if so, when will it lift? Are there clouds that indicate unstable air which may influence the fire?
- **Fire Behavior** - How is the fire burning? Is it making runs, or just "skunking around"? Do you expect the fire behavior to change? Is the level of fire behavior modifying the direction and speed of local winds?

Indicators, like traffic road signs, can warn you of danger.

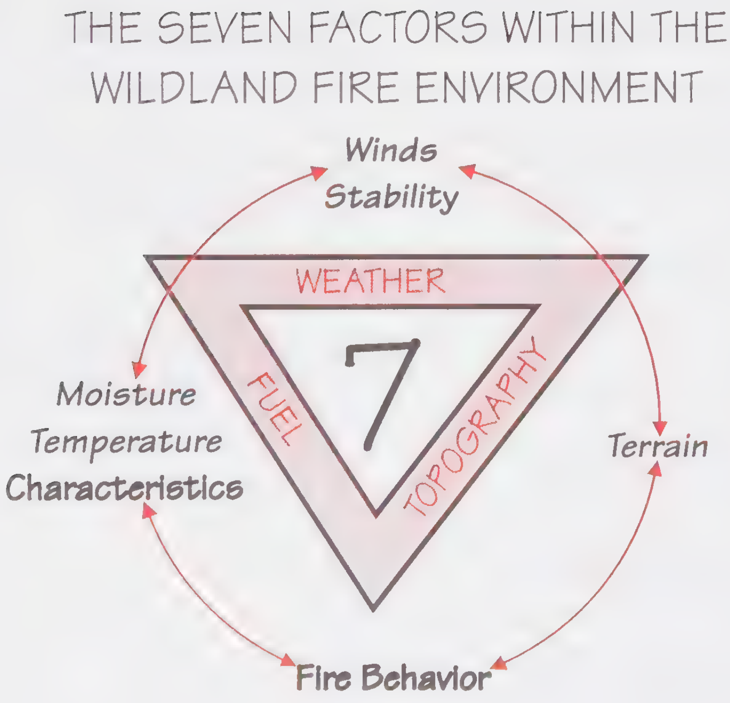


Figure 5.1 The seven factors within the fire environment. These must be monitored throughout the fire fight.

The phrase, "Look Up, Look Down, Look Around," refers to these seven characteristics. These are the things you should be looking for! (Figure 5.2).

Fuel Characteristic Indicators

None of these extreme events will occur if there is not enough fuel to sustain it. Fuel characteristics change very slowly, but the type of fuel can change as the fire moves through an area. Look and see what is burning currently, and what type of fuel is close by and may burn soon (Figure 5.3).

Fine fuels are involved with the spread of most wildland fires. Continuous fine fuels provide the potential for rapid rates-of-spread. Remember, fine flashy fuels are one of the common denominators of fatal fires.

Heavy fuels can also spell disaster. An accumulation of dead- and down-fuels can set the stage for an intense fire that may burn for a long period of time. The ratio of dead-to-live fuels, and areas that have been logged, should also be of concern.

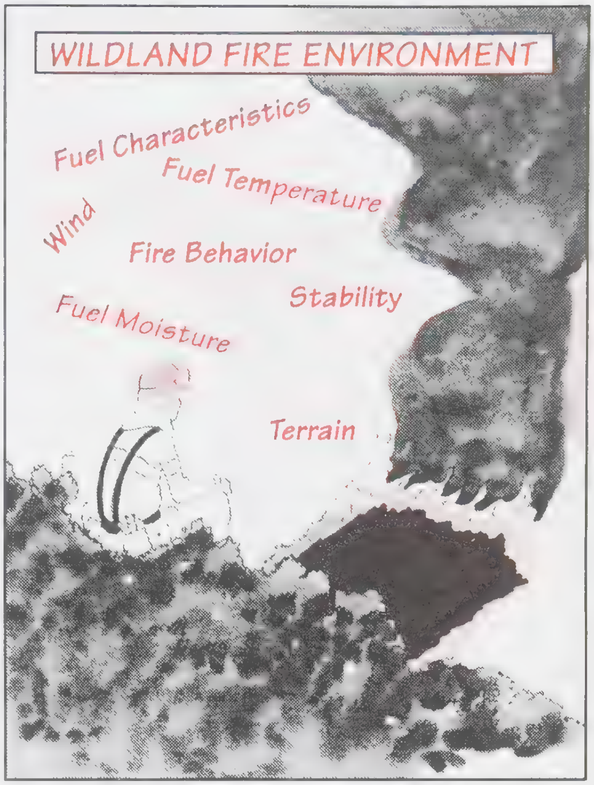


Figure 5.2 This fire officer is observing the fire environment. Is he finding what he needs to find?

Another important factor is the arrangement of the fuels. Are there ladder fuels that will allow the fire to move into the tops of the fuels (trees, brush, etc.) and start a crown fire? The higher the intensity of the fire on the ground, the less ladder fuels that will be needed to move the fire into the tops of the fuel. Brush and young tree reproduction are some of the more common ladder fuels.

Spacing of the fuels is another factor controlling crowning. If the spacing of the crowns is less than 20-feet, you have the potential for a crown fire. However, you can still have a crown fire with wider spacing, especially on a steep slope or when there is a strong wind present.

Fine fuels are involved with the spread of most wildland fires. They are also one of the common denominators of fatal fires.

There are also some special fuel conditions that you should consider. Are there snags in the area? They are good sources of firebrands, and are also places where firebrands will ignite spot fires. Has the area been hit by bugs or frost, killing a lot of trees? Is there snow damage that has increased the ratio of dead-to-live fuels? Is the area suffering from drought? All of these are special factors that play a role in the fire environment.

One of the more deadly situations is when a low intensity fire has moved through an area burning the understory. The upper-level fuels have been dried out and can burn with extreme intensity. Reburns have been the cause of many serious accidents.

Reburns can kill!

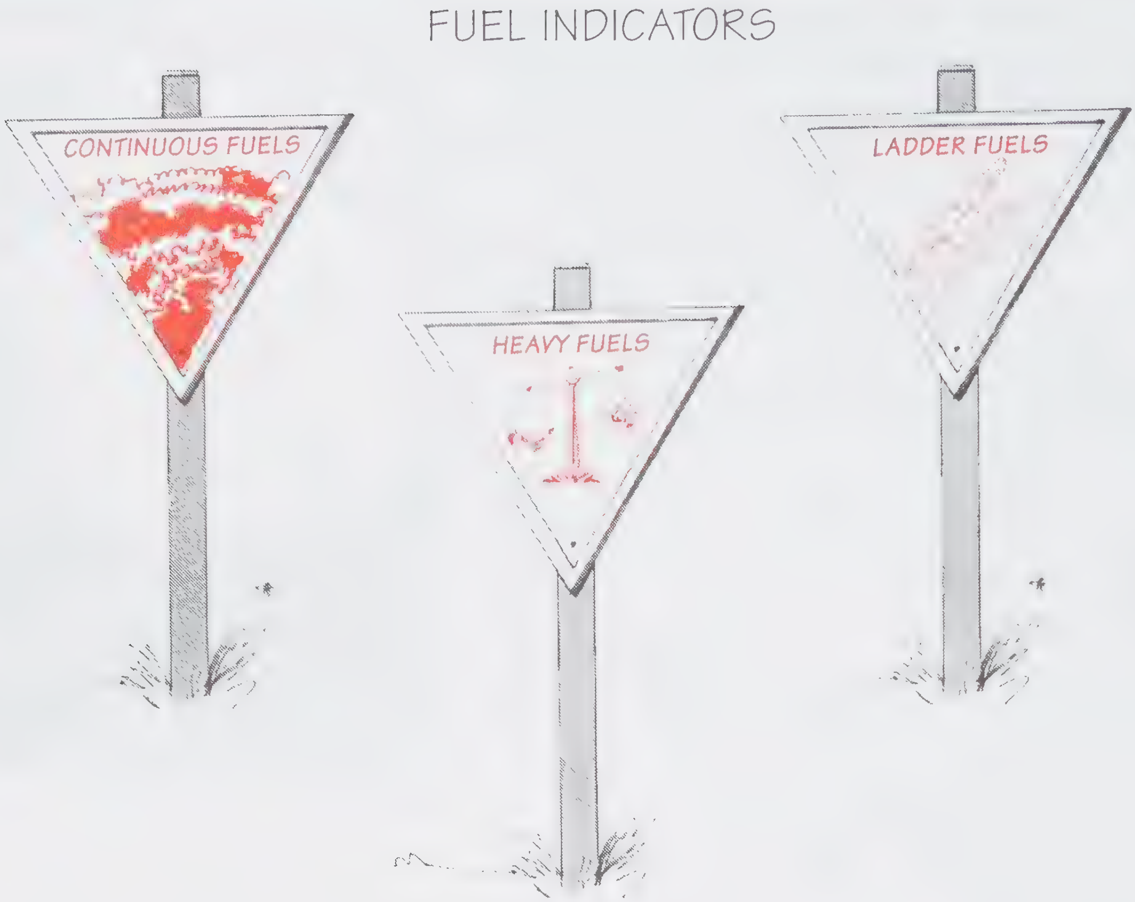


Figure 5.3 You need to understand fuel characteristics and their influence on fire behavior. There are many warning signs.

Fuel Moisture Indicators

Fuel moisture determines if fuels will be "available" to burn. Fine fuel moisture changes constantly and quickly. That is one of the reasons why fine fuels are involved in many fatal fires. A good way to track the fuel moisture of fine fuels is to measure the relative humidity. In most areas a relative humidity of 25 percent or less will allow fine fuels to burn with considerable intensity. The larger or 10-hour fuels are less reactive to relative humidity, but they can be "tested" by bending them. If they break easily, they are dry and will burn. If they bend, their moisture content is higher. They may still burn, but with less intensity. 10-hour fuels with a fuel moisture content below 7 percent are an indicator of dry conditions.

The best way to track fine fuel moisture is to track the relative humidity.

The large dead fuels (usually called the 1000-hour fuels) also play a part in the equation. In the high country where there is considerable snowfall, these fuels don't begin to influence fire behavior until summer, after they have had time to dry out. If there is a drought, or there was an early spring, these fuels may come into play earlier. If you are told the 1000-hour fuels are 20 percent, you know that they will burn. If they get into the low teens, they are very dry and should be of real concern (Figure 5.4).

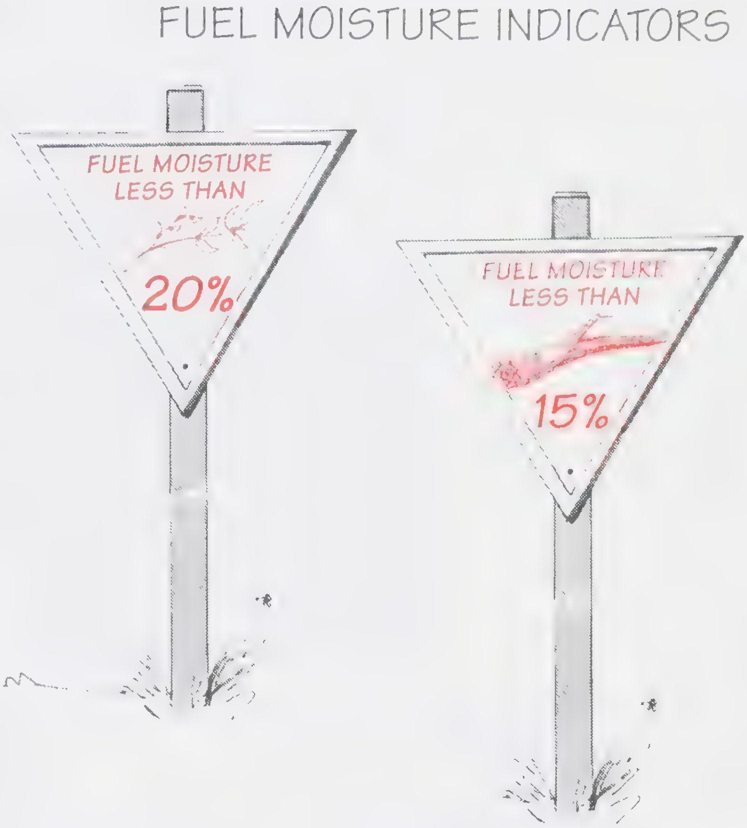


Figure 5.4 Fuel moisture warning signs.

Wildland fuels normally dry in a sequence. The finer fuels, pine needles, and grasses dry out first. The next fuels to dry are the 10-hour and larger fuels. The last fuel class is the drying of the live fuels. You can see that, as the season progresses, more fuels will become "available" to be burned.

Fuel Temperature Indicators

The temperature of fuels is directly related to how much heat it will take to ignite the fuel. If the fuels are cold, it takes more heat energy to bring the fuels up to the point of ignition.

If a fuel is shaded, it will be considerably cooler than adjacent fuel that is exposed to direct sunlight and solar radiation. This condition changes as the sun moves through the skies. The topographic aspect, as it relates to the position of the sun, is an indicator of fuel temperature. You should pay attention to aspect, position of the sun, and fuel temperature, because these factors will definitely affect fire behavior (Figure 5.5).

Aspect can be very influential on how a fire will burn.

ASPECT AFFECTS FUEL FLAMMABILITY

These fires are burning in the same area, same fuel type, and at the same time, about 0900 hours in the morning.

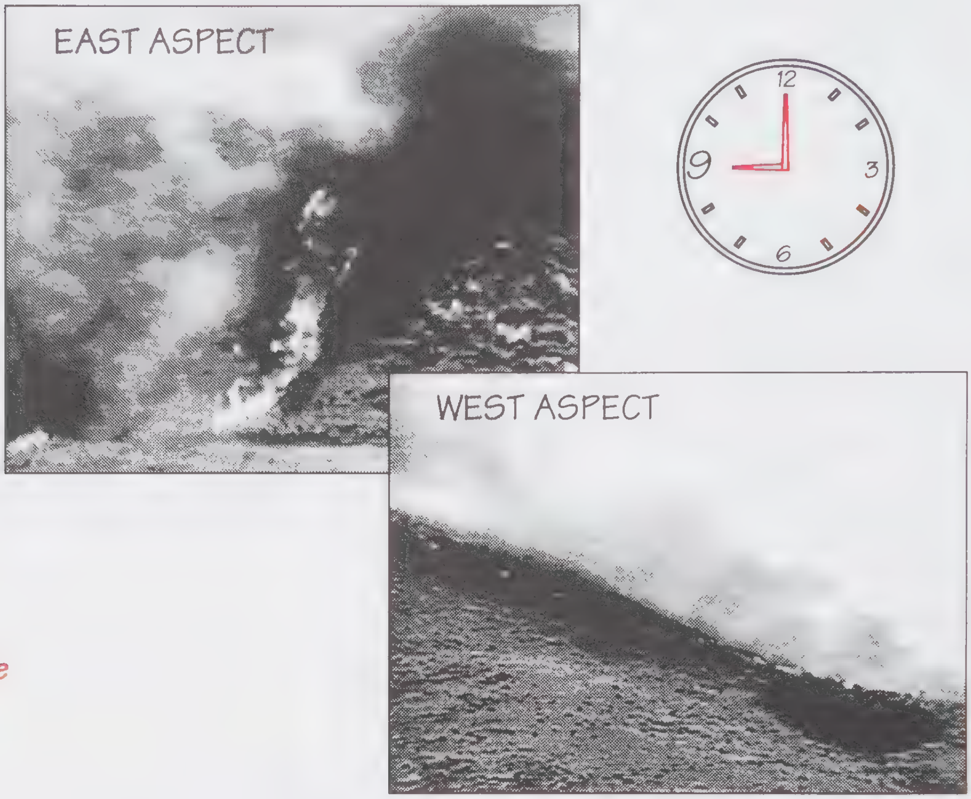


Figure 5.5 The warning signs for fuel temperature are aspect and exposure to direct sunlight. These indicators vary throughout the day.

Slopes affect fire behavior.

Terrain Indicators

The terrain or topography of an area directly affects both the rate and direction of fire spread. Although the topography is fixed, where the fire burns in the terrain is constantly changing. You must have a feel for the terrain in which the fire is burning, as well as what is ahead. Study the terrain for its relationship to the wind and sun (Figure 5.6). Watch for terrain indicators that warn of changes in fire behavior:

Box canyons or chutes can cause a fire to burn very erratically.

- **Steep slopes** have a dramatic effect on fire behavior. Not only do steep slopes allow a fire to move quickly uphill, they also allow burning material to roll downhill. Steep terrain is one of the common denominators in fatal fires.

- **Box canyons or chutes** can act like a chimney, channeling both wind and fire. This channeling can cause very rapid rates-of-spread.
- **Saddles** are another terrain feature that you should be concerned with. They also cause a channeling effect that can contribute to rapid rates-of-spread. Fireline constructed on ridge lines most likely will cut across saddles. These low spots on the ridge line are not places to park vehicles or spend a lot of time if fire is below you.
- **Narrow canyons** pose another problem. As a fire backs down one side of the canyon, its narrowness allows for preheating of the other slope. Narrow canyons increase the chance of spot fires, which can jeopardize the safety of anyone in the canyon floor. When the fire does reach the bottom of the canyon, slope reversal can occur. Rapid rates-of-spread can be expected. Intersecting drainages should be of concern, because they can cause erratic winds and increased fire behavior.

Stay out of saddles.

A fire can easily spot across narrow canyons.

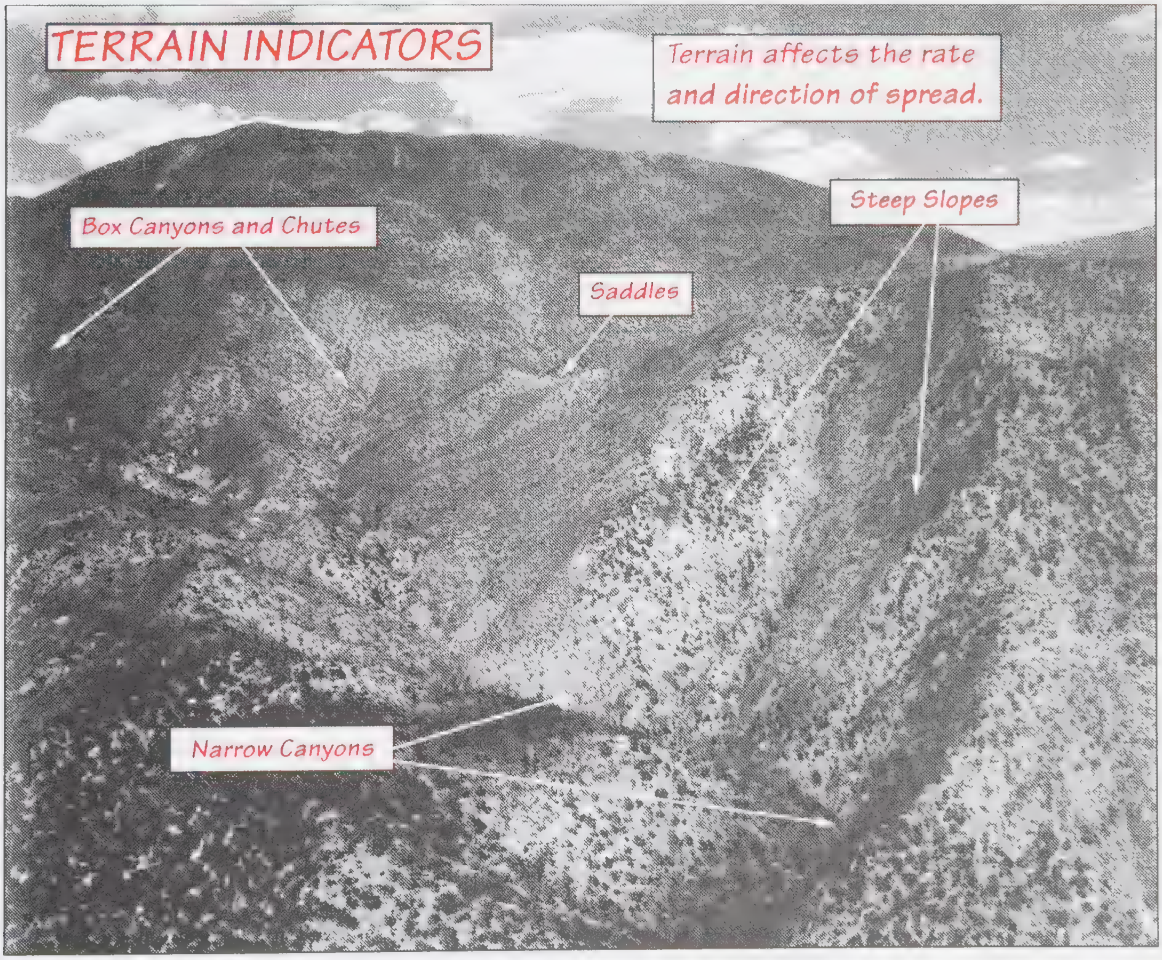

TERRAIN INDICATORS
Terrain affects the rate and direction of spread.
Box Canyons and Chutes
Steep Slopes
Saddles
Narrow Canyons

Figure 5.6 There are several terrain indicators to watch for: steep slopes, box canyons, chutes, saddles, and narrow canyons.

Wind Indicators

Wind is the most influential factor when it comes to the fire's rate and direction of spread (Figure 5.7). Moderate to strong winds provide a means for wind-driven fire runs, and for transporting firebrands. Generally, a wind of just 10 miles per hour can cause rapid rates-of-spread.

Wind is the most influential factor when it comes to the fire's rate and direction of spread.

Wind can be measured in several ways. It can be directly measured using the wind gauge in your weather kit. Or, you can use the Beauford Scale to estimate the wind speed (Figure 5.8). In general terms, a wind of 5 miles per hour will cause the leaves of a tree to flutter and move. A wind of 10 miles per hour will cause standing single trees to sway from side to side. At 15 miles per hour there will be considerable movement in the brush and timber, and dust will be stirred up.

If you see a "lens" shaped cloud, it indicates the presence of strong winds.

The clouds can also be an indicator of wind conditions. Lenticular clouds (Figure 2.37, page 71) indicate strong winds at high elevations. These clouds form when strong winds pass over a mountain range. There is the potential that the wind may surface on the lee side (the side under the lenticular cloud), causing strong downslope winds.

Fast moving clouds indicate high winds, and may be "predicting" a wind shift. Be especially alert if the clouds are moving in a direction different from the surface winds.

Approaching cold fronts are another concern. As they move through an area, they bring shifting winds and increased wind speeds. Some cold fronts have squall lines of thunderstorms that you can see as they approach. But the first indication that a dry, cold front is passing through is a change in wind direction. The effects of a passing cold front should not be underestimated. If you have any active fire near control lines, especially on the south and east flanks, be very careful.

The effects of a passing cold front should not be underestimated.

Thunderstorm buildups in an area can cause strong, erratic winds. If you see mid-level puffy, clouds in the morning, they may be altocumulus castellanus clouds (Figure 2.35, page 70). These clouds indicate instability, and are a strong indicator that thunderstorms are possible later in the day.

WIND INDICATORS

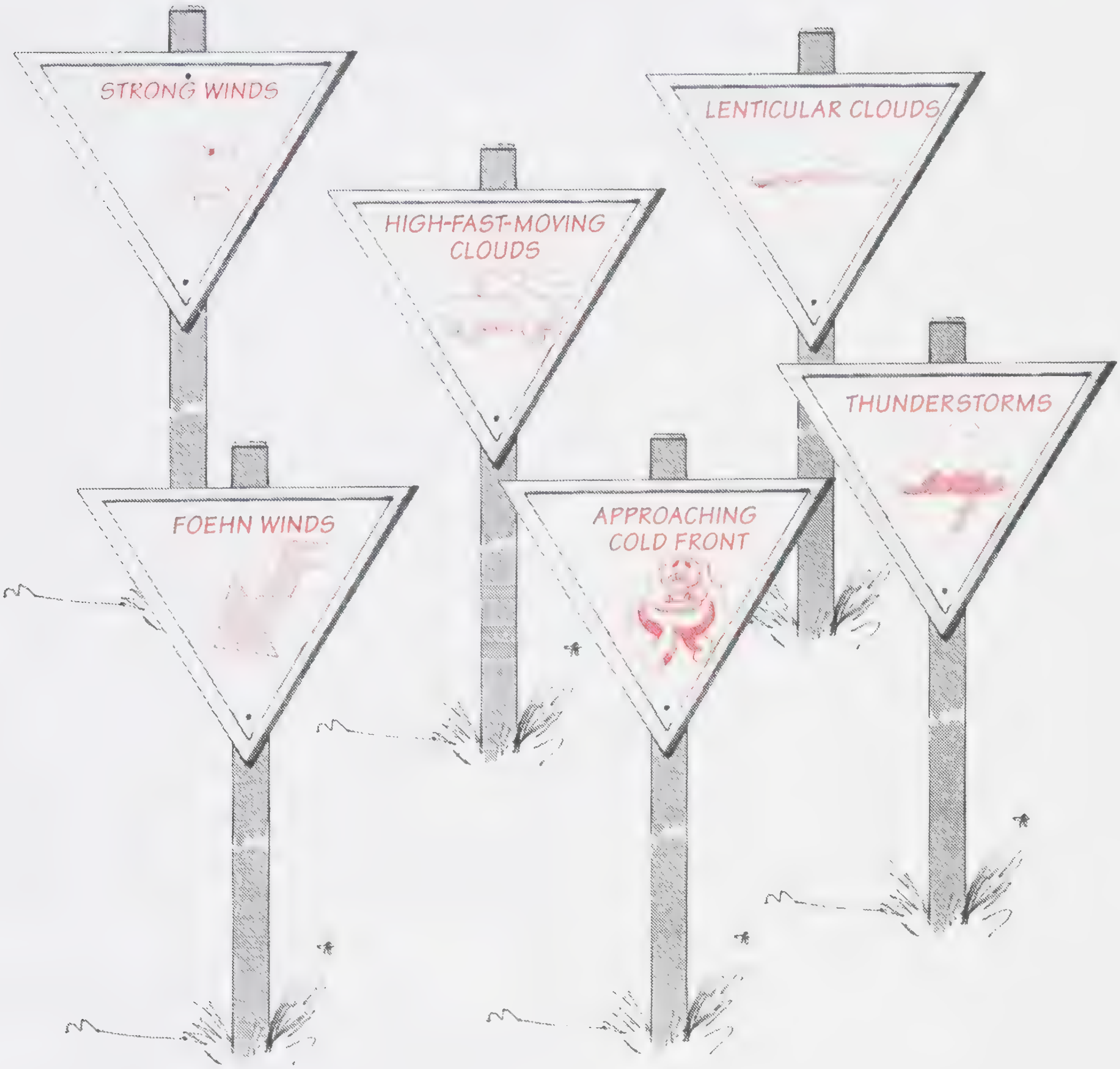

STRONG WINDS
LENTICULAR CLOUDS
HIGH-FAST-MOVING CLOUDS
THUNDERSTORMS
FOEHN WINDS
APPROACHING COLD FRONT

Figure 5.7 Wind indicator warning signs.

A thunderstorm can develop very quickly, sometimes in less than 30 minutes. As a thunderstorm builds, air is moved toward the base. Once the cloud is mature, violent downdrafts may occur. Downdrafts are strong winds that move downward inside the storm. If you see virga (rain that isn't reaching the ground) the downdrafts more than likely have begun. When they hit the earth's surface, they can travel in all directions. If this occurs close to or over a fire, it can be "spectacular"; fire will go in all directions. If you have a thunderstorm within 10 miles of your fire, be prepared for strong, erratic winds.

A thunderstorm can affect fire behavior on fires within 10 miles.

MODIFIED BEAUFORD SCALE FOR ESTIMATING 20-FOOT WIND SPEED

Wind Class	Range of Speeds (mph)	Nomenclature
1	3 or less	VERY LIGHT - Smoke rises nearly vertically. Leaves of quaking aspen in constant motion; small branches of bushes sway; slender branchlets and twigs of trees move gently; tall grasses and weeds sway and bend with wind; wind vane barely moves.
2	4 - 7	LIGHT - Trees of pole-size in open sway gently; wind felt distinctly on face; loose scraps of paper move; wind flutters small flags.
3	8 - 12	GENTLE BREEZE - Trees of pole-size in the open sway very noticeably; large branches of pole-size trees in the open toss; tops of trees in dense stands sway; wind extends small flag; a few crested waves form on lakes.
4	13 - 18	MODERATE BREEZE - Trees of pole-size in the open sway violently; whole trees in dense stands sway noticeably; dust is raised in the road.
5	19 - 24	FRESH - Branchlets are broken from trees; inconvenience is felt in walking against wind.
6	25 - 31	STRONG - Tree damage increases with occasional breaking of exposed tops and branches; progress impeded when walking against wind; light structural damage to buildings.
7	32 - 38	MODERATE GALE - Severe damage to tree tops; very difficult to walk into wind; significant structural damage occurs.
8	39 or over	FRESH GALE - Surfaced strong foehn winds; intense stress on all exposed objects, vegetation, buildings; canopy offers virtually no protection; wind flow is systematic in disturbing everything in its path.

Figure 5.8 Beauford Wind Scale.

Foehn or gravity winds can also cause problems. These winds are so notorious, they have been given special names, for example, Santana, Mono, and Chinook. Foehn winds are the result of high-pressure systems moving air over mountain ranges. As this occurs, the air is heated and dried by compression. These winds can last for hours or days. They are very predictable. When they blow, the wind is normally from one direction. As they begin to degrade or weaken, local winds may begin to move in. This can cause wind reversals in just minutes. This "battling of winds" is especially prevalent along the Southern California coast, where the Santanas do battle with the onshore winds from the Pacific Ocean. A sudden calming of winds, or a shifting or wavering smoke column, are both indications that the wind direction will be changing. This type of event doesn't have to be right on the coast. It can occur some miles inland.

Foehn winds are very predictable.

Atmospheric Stability Indicators

Stability refers to the resistance of the atmosphere to vertical (up and down) movement. The chance of extreme fire behavior increases as the atmosphere becomes unstable. An unstable atmosphere allows a fire to develop "vertically" and grow rapidly (Figure 5.9). Some of the best indicators of unstable conditions are:

- Good visibility.
- Gusty winds, dust devils and firewhirls.
- Cumulus or castellanus clouds.
- Smoke columns rising straight up.
- The breaking down of an inversion layer.

An unstable atmosphere allows a fire to develop "vertically" and grow rapidly.

This last indicator, the breaking down of an inversion layer, needs discussion. An inversion layer exists when the atmosphere is stable (no vertical movement of air) and a warmer layer of air tops a colder air mass. When this warmer air mass is relatively thin, it is called a thermal belt. In this belt the air will be warmer and dryer. Fires burning in an area that falls within this belt will burn with greater intensity than fires above or below it.

When an inversion layer breaks down, fire behavior will pick up.

When an inversion is present, fire behavior below it will normally be subdued. However, conditions will be very smoky and very hard on firefighters that have to work at a level within the inversion layer. As the day begins to warm up and the air becomes unstable, the inversion layer will begin to break down. You may recall from the chapter on weather that the atmosphere becomes unstable when winds begin to mix the air layers, and when solar radiation begins to heat the earth's surface, causing the air to lift. If you know the country, you will be able to predict when an inversion layer will begin to break up. This is the time to be alert and cautious.

Inversion layers tend to break down about the same time each day.

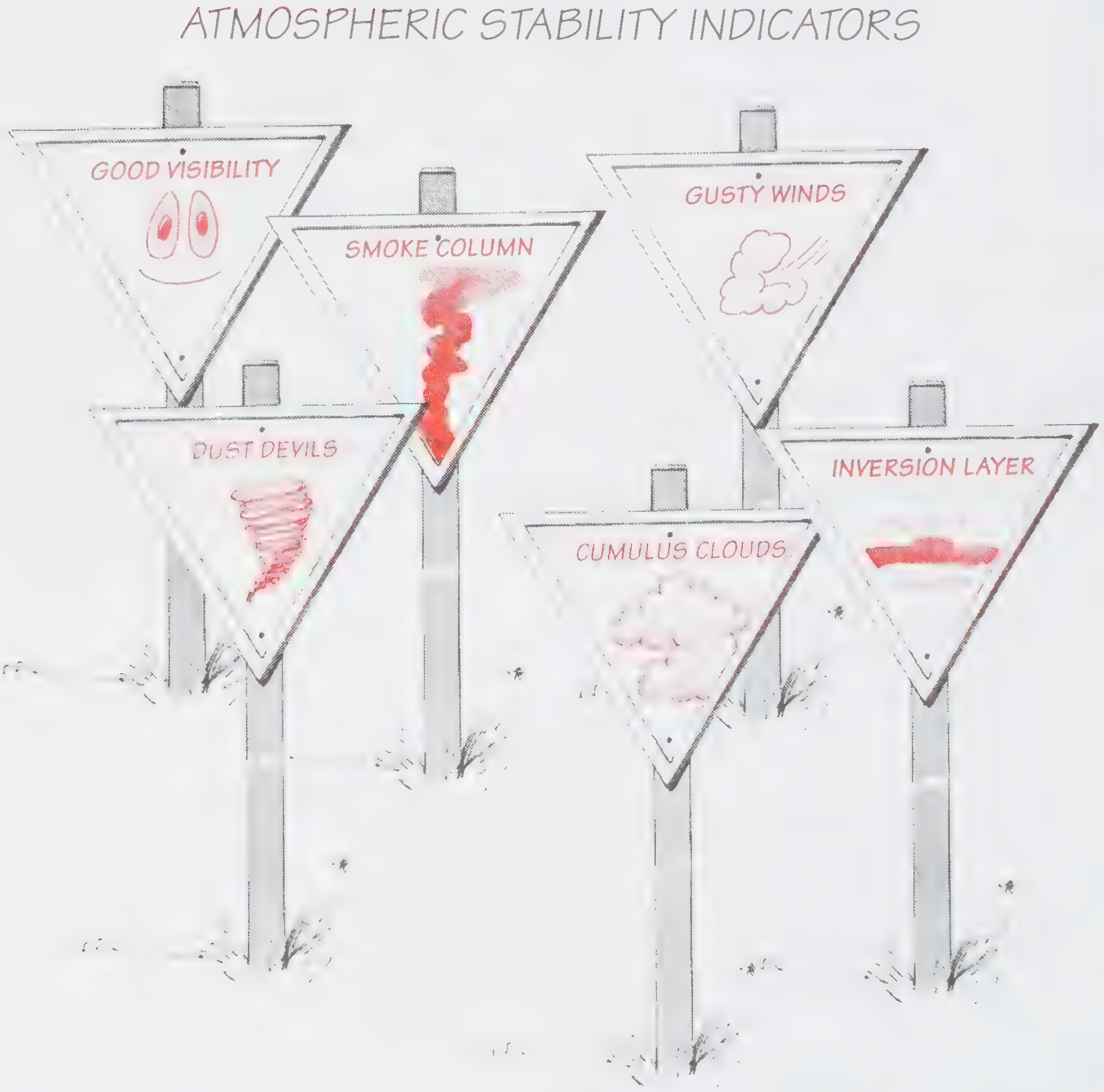

ATMOSPHERIC STABILITY INDICATORS
GOOD VISIBILITY
SMOKE COLUMN
GUSTY WINDS
DUST DEVILS
INVERSION LAYER
CUMULUS CLOUDS

Figure 5.9 These are the indicators of unstable conditions. An unstable atmosphere allows a fire to develop "vertically" and grow rapidly.

Fire Behavior Indicators

Fire develops in stages. There are several fire behavior indicators which can help you predict what a fire will do (Figure 5.10). These indicators are:

- **Smoke column** - One of the best indicators of fire behavior is the smoke column (Figure 5.11). If it is **leaning**, this is an indication of a wind-driven fire, one with a rapid rate-of-spread and short-range spotting. If the smoke column rises to some height and then is flattened off, this is a **sheared** smoke column. Strong upper-level winds are cutting off the top of the smoke column. With this situation, you have the potential for long-range spotting and strong surface winds (if the upper-level winds come down to the surface). If the smoke column is **well developed**, rises to considerable height, and is capped with a very white cloud, you can expect intense burning conditions and unpredictable fire spread in all directions. If there is a light rain or the wind becomes calm, "watch out!" There is the possibility of downbursts. If the smoke column is **changing color** or **beginning to rotate** or roll, this is an indicator that conditions are changing and the fire behavior is going to pick up.
- **Trees torching** - If trees are beginning to torch either one at a time or in groups, the situation is getting worse. This change means the relative humidity is dropping.
- **A smoldering fire that is beginning to pick up** - If the fire you are on has been just "skunking around" and not doing much, then suddenly begins to burn with some vigor, conditions have changed and it is time to "watch out!" This increase in fire behavior could be the result of high temperatures, lower relative humidities, or an increase in wind. More than likely, it is a combination of all three factors.
- **Firewhirls** - The presence of firewhirls is not just an indicator of unstable air, but an indicator that the fire is going vertical; it is developing a strong convection column. The fire may be on the verge of crowning. Firewhirls may cause an increase in the level of spotting.
- **Spot fires** - If you are beginning to have more spot fires than you can handle, this is a sign that conditions are deteriorating rapidly.

"Reading" the smoke column can aid in predicting what a fire is doing.

If trees are beginning to torch, the fire behavior is changing.

Fire whirls are a good indication that the atmosphere is unstable.

It is your responsibility to track the weather and the associated fire behavior. You may have to use lookouts to aid you, but you should be the primary observer. As you track the fire's behavior, several of these indicators may catch your attention at the same time. However, even one indicator may be a "heads up" to changing conditions. If you sense a change, you must review your strategies and tactics to see if they, too, must change.

Extreme Fire Behavior Contributing Factors

The previous section discussed the characteristics or warning signs of extreme fire behavior. This section will attempt to show how various contributing factors work together to actually cause a fire to move into the third dimension.

When a fire begins to develop vertically into a third dimension, it begins to respond to processes that the fire is creating. For example, if a fire generates enough heat to break through an

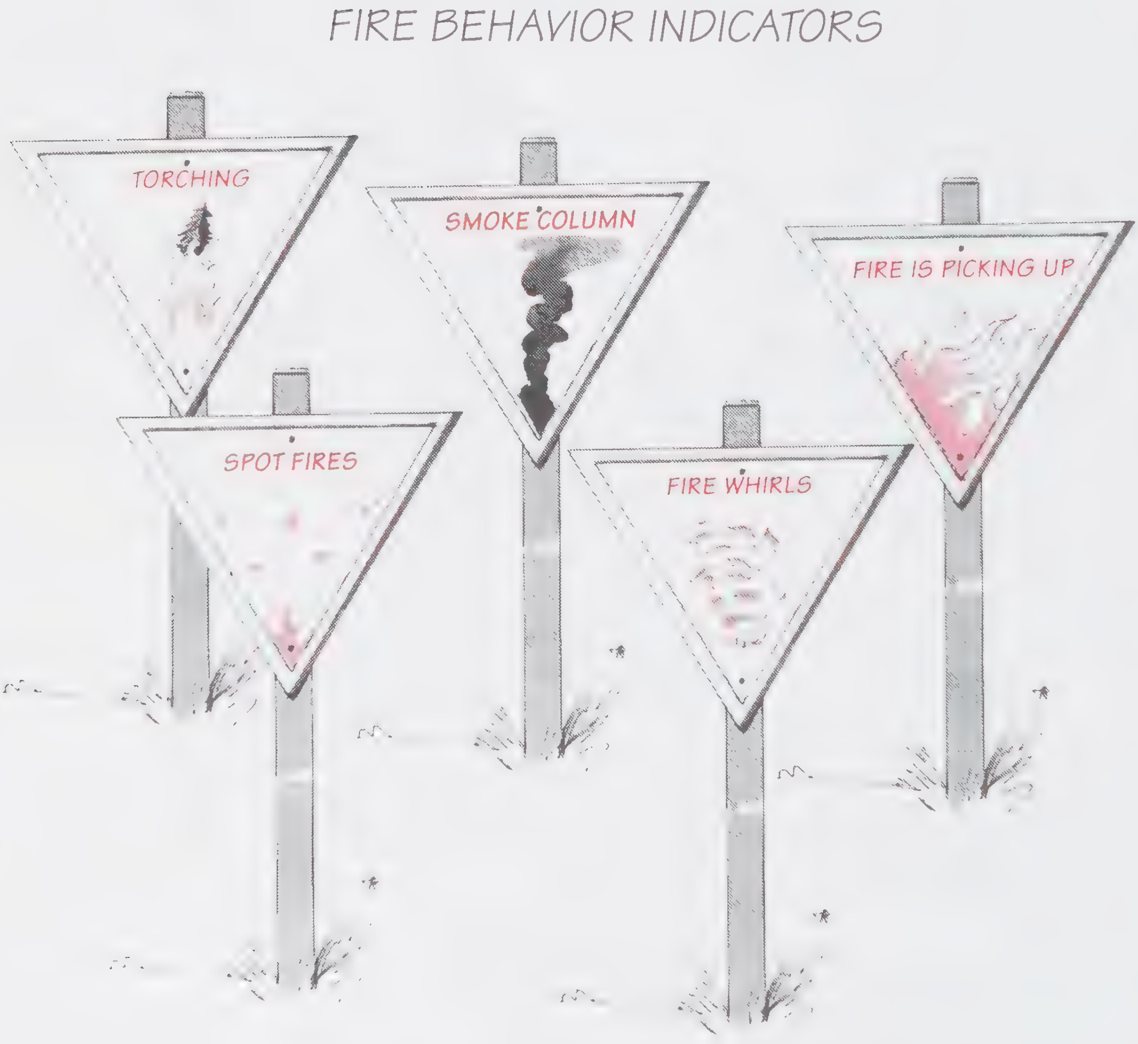

FIRE BEHAVIOR INDICATORS
TORCHING
SMOKE COLUMN
FIRE IS PICKING UP
SPOT FIRES
FIRE WHIRLS

Figure 5.10 Learn to recognize the various indicators of fire behavior.

inversion layer, the vertical rush of hot gases will be replaced with cooler air. This rush of air toward the fire is in the form of a wind, generated by the fire itself.

There are several environmental factors that contribute to extreme fire behavior. They are the availability of fuel; a wind event; and a dry, unstable air mass.

- **Available fuels** - The fire needs fuel to generate the heat intensity needed to produce a rapid rate-of-spread, lift firebrands to considerable heights, or develop strong convective wind patterns. If fuels have been stressed or killed by drought, bugs, disease, a freeze, or wind, the available fuels will be increased (Figure 5.12).
- **Wind** - Winds capable of producing extreme fire behavior can be the result of several weather conditions. The winds could be associated with the passage of a front (e.g., South Canyon and Point fires), or as a result of a foehn or gravity wind (Santana or Chinook winds). The wind provides oxygen, but more importantly, it facilitates the transfer of heat from the burning fuels to the unburned fuels. This transfer can be in the form of a direct transfer, e.g., moving the flames closer to the fuels, or by carrying firebrands out in front of the fire (Figure 5.13).
- **Low atmospheric moisture content** - Dry air means drier fuels. The drier the fuels, the easier it is for them to ignite.
- **Unstable air mass** - If there is instability in the atmosphere, there is a greater chance that the fire will develop a strong convective action. That, in turn, creates a wind that will further intensify the fire (Figure 5.14).

A fire can develop its own wind.

Drought adds to the availability of fuels.

Wind aids in the transferring of heat from the fire to unburned fuels.

If the atmosphere is unstable, there is a greater chance for the fire to develop a strong convection column.

Crown Fires

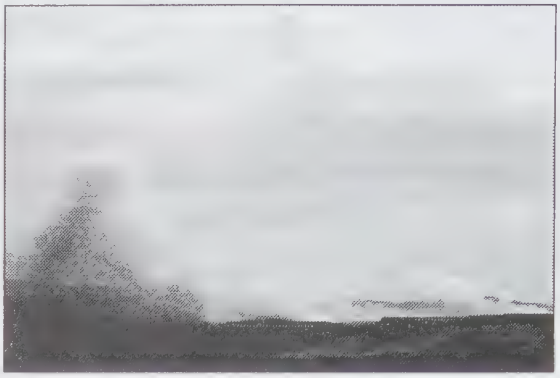
Crown fires are one of nature's most dramatic and spectacular events. They are also the fastest spreading of all fires. It is not uncommon for a crown fire to move at a rate of 5 miles per hour or more. Crown fires not only occur in heavy timber fuels, but also in the canopies of tall shrubs, brush, chaparral, plantations, and such.

Crown fires develop in three progressive stages: passive, active, and independent. Crown fires begin as an individual torching tree or bush. If conditions are right, the torching fuel will cause other trees to torch, and a crown fire is born. Sometimes the crown fire will move back to the surface, then back into the

READING THE COLUMN OF SMOKE

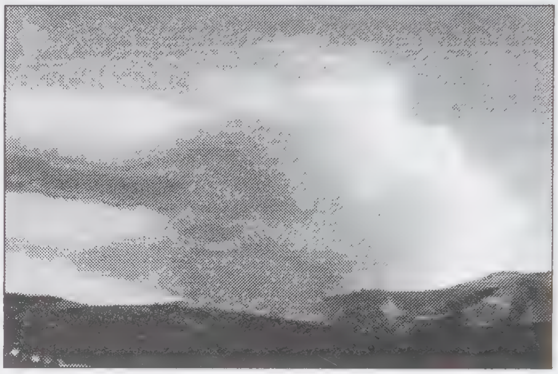
Leaning Smoke Column

- A wind driven fire.
- Rapid rates of spread.
- Short range spotting.



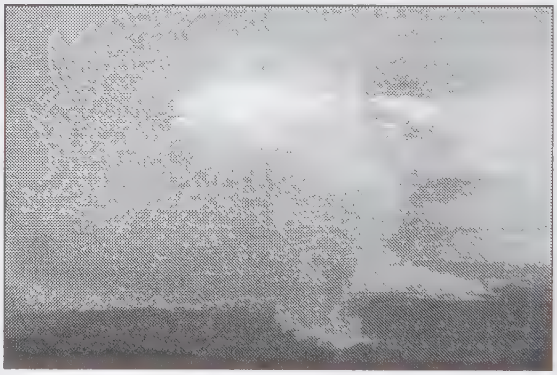
Sheared Smoke Column

- Smoke rises straight up.
- Column is sheared off by strong winds aloft.
- Potential for long range spotting.
- Strong winds could surface.



Well Developed Smoke Column

- Intense burning conditions.
- Unpredictable fire spread in all directions.
- Look for capped top.
- Strong downburst potential.
- Light rain or calm indicate possible downbursts imminent.



Changing Smoke Column

- Beware when the column begins to change color or rotate.

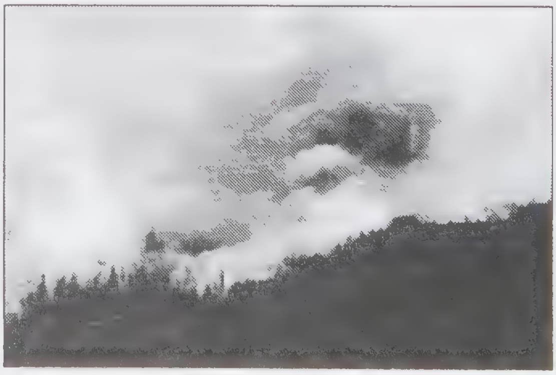
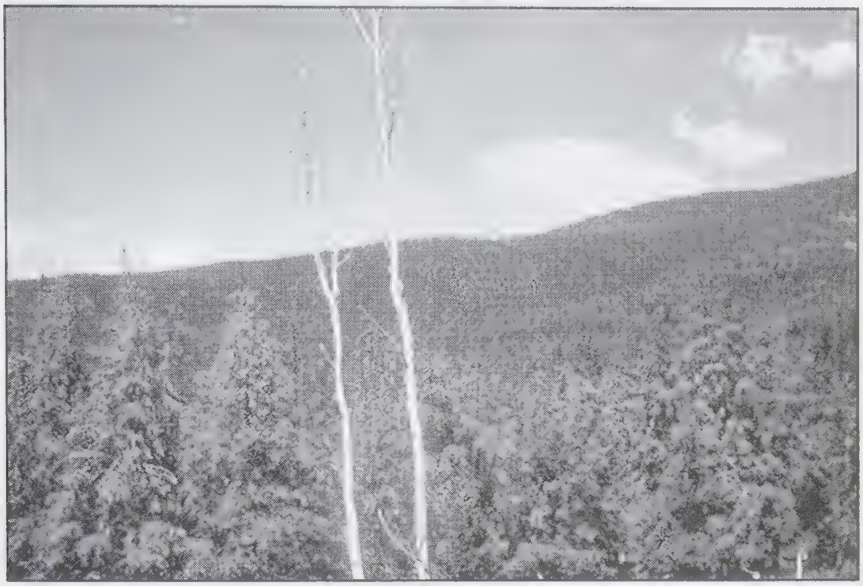


Figure 5.11 You can learn a lot about fire behavior by "reading" the smoke column.



Large, unbroken fields of fuels can contribute to blowup conditions.

Figure 5.12 Available fuels must be present before a fire can "blowup" and move into the third dimension. Anything which dries or kills the fuels will contribute to their availability to burn.

Wind can carry firebrands for miles.

Figure 5.13 Wind may be a factor in an extreme fire behavior event. A wind will increase the availability of oxygen, facilitate heat transfer, and carry firebrands ahead of the fire front.

crowns again later. Each of the stages of a crown fire present a different challenge.

- **Passive crown fire** - A passive crown fire is usually confined to one tree or a small grouping of trees (Figure 5.15). This stage of crown fire is commonly called "torching out." A passive crown fire is entirely at the mercy of a surface

Crown fires can occur in most fuel types. They are not limited to timber.

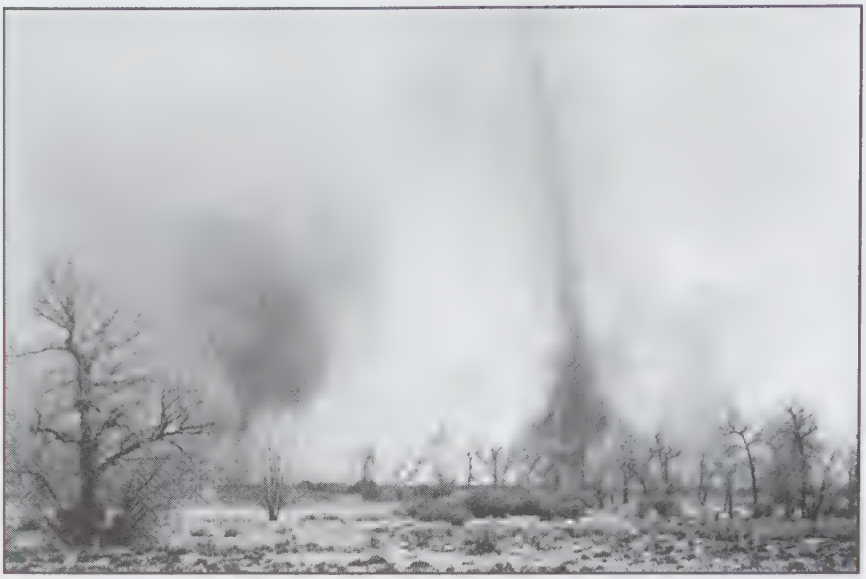


Figure 5.14 Unstable air will allow a fire to move vertically.

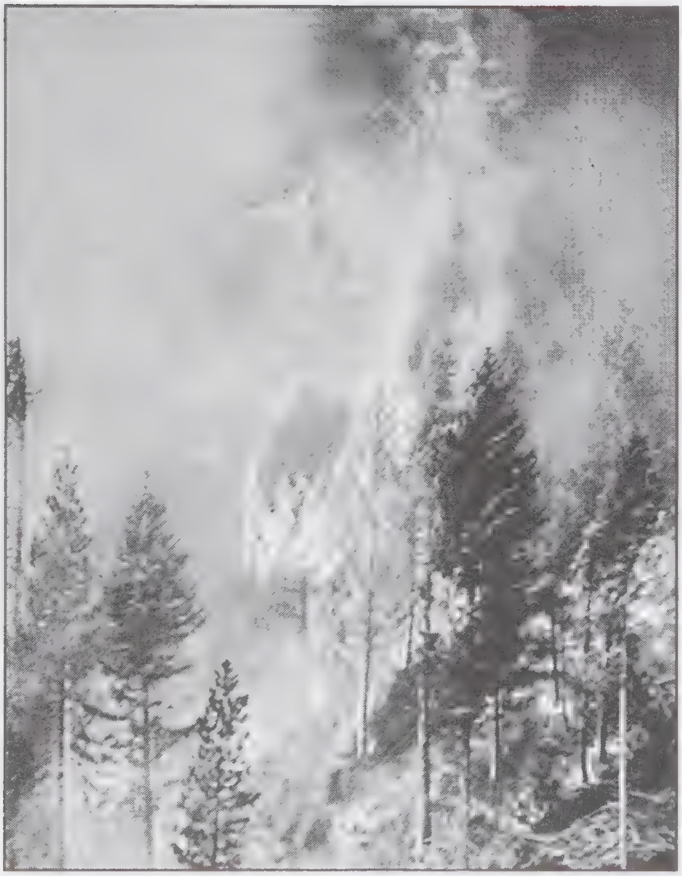


Figure 5.15 A passive crown fire, commonly referred to as "torching out," is usually limited to closely spaced trees.

fire and the availability of ladder fuels. This torching out is usually short-lived and confined to trees which are closely spaced. This type of crown fire may cause localized spotting.

- **Active crown fire** - An active crown fire is also dependent on the surface fire, but there is much more transfer of heat from one burning crown to the unburned crowns of other trees (Figure 5.16). The crown fire may run ahead of the surface fire, or the surface fire may precede the crown fire. Active crown fires often pulsate, moving from the crowns down to the surface and back into the crowns again. Be very careful when a fire is in this stage of activity.
- **Independent crown fire** - An independent crown fire gets its name from the fact that it is not dependent on the surface fire for its energy (Figure 5.17). The energy that supports this kind of crown fire is developed in the crowns as the fire moves from one crown to another. The surface fire spread is the result of the crown fire. Independent crown fires are not very common, but when they do occur, it is time you drop back and become an observer. There is nothing you can do to stop this type of event. Just get out of its way.

There are several environmental conditions which can contribute to the possibility of a crown fire. One of the conditions is the **crown flammability** of the fuel. A higher **ratio of dead-to-live fuels** will influence the ease with which a fire will move into the crowns. Low fine fuel moistures promote crown flammability. The moisture content of the live fuels is also a factor. **Live fuel moisture** is controlled by the stage of growth, which is related to the time of year. In the spring when the fuels are actively growing, the fuel moistures will be much too high to support a crown fire. Some fuels, like chamise, jack pine, and palmetto/gallberry, include **volatile oils** that support combustion. This makes them more susceptible to crown fires. **Crown closure** of 75% or more will contribute to the chance of a crown fire.

Crown fires can move from the tops of the fuel to the ground and back to the crowns.

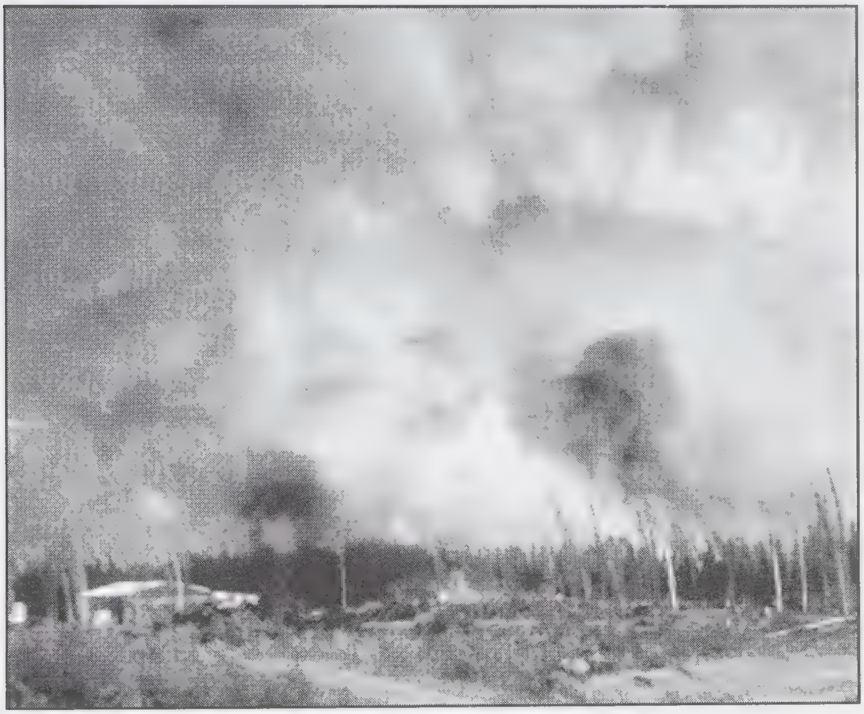


Figure 5.16 An active crown fire often pulsates, moving from the surface to the crowns and back to the surface again.

When a tree "torches," it is a form of crown fire.

Independent crown fires are not dependent on a surface fire for their energy.

All crown fires start as a surface fire (Figure 5.18). Several factors control the ease with which crowning occurs. The greater the **surface fire intensity,** the more likely it is that the fire will move into the crowns. Heavy fuel loading, loosely compacted

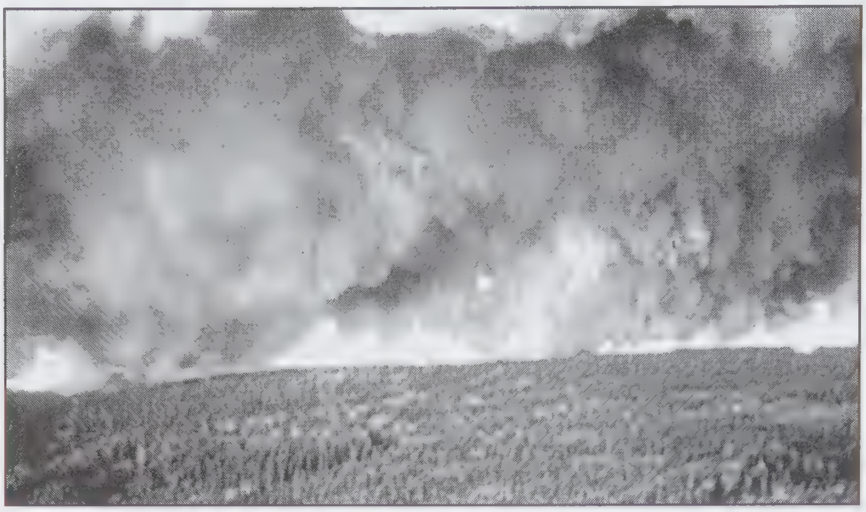


Figure 5.17 Crown fires are the most recognizable examples of extreme fire behavior. The flame lengths in this picture are well over 100-feet.

Crown fires are spectacular and can move quickly.

fuels, low fuel moisture contents, and unstable atmospheric conditions all impact the intensity of the surface fire. The **vertical arrangement of the fuels** is also a factor. If there are ladder fuels or low crown foliage, it will take less surface fire intensity to move the fire into the crowns. The **steepness of the slope** is also a factor in crowning. The steeper the slope, the shorter the distance between the surface fire and the crowns.

Live fuel moisture is controlled by the stage of growth.

Another contributing factor in crown fires is **crown-to-crown heat transfer** (Figure 5.19). Both active and independent crown fires spread from crown-to-crown. Heat transfer between aerial fuels occurs more readily under certain conditions. **Crown spacing** of 20 feet or less (roughly 100 trees per acre) will permit convective and radiant heat transfer to occur at a level of intensity that can maintain a fire spreading through the crowns. **Crown level winds** of 20 miles per hour or more will permit and sustain convective and radiant heat transfer. The ease of crown-to-crown heat transfer is also affected by **steepness of slope**.

All crown fires start as a surface fire.

For a crown fire to sustain its run, several conditions are needed:

- Low fuel moisture.
- Relatively close crown spacing.
- Strong winds and/or steep slopes.
- The ability to spot ahead in discontinuous fuels.

Under the right conditions, an active or independent crown fire may sustain a run for miles (Figure 5.20). In 1988, at the same time Yellowstone National Park was on fire, the Canyon Fire, in central Montana, had a run of over 20 miles in one evening. Normally, however, changes in environmental conditions or fuels will end crown fires long before they move miles.

Crown spacing, crown level winds, and the steepness of slopes influence a crown fire.

Spot Fires

When a fire moves into the third dimension, spotting may be the result. Such spotting is the result of firebrands being carried by convective action and/or the wind. Spotting can also be caused by rolling material.

There are several factors to consider when analyzing spotting potential. They are:

- **Probability of spotting** - The probability of spotting is directly related to the intensity of the surface fire, burning conditions, overstory species, crown spacing, etc. On the other hand, cover canopy may intercept the upward travel of firebrands and limit the spotting problem.
- **Number of firebrands** - Most firebrands do not start fires. They either burn out before landing, land in an area where there is no fuel, or land in fuel that will not ignite. However,

Figure 5.18 All crown fires start on the ground. Surface-to-crown heat transfer is controlled by surface fire intensity, vertical arrangement of the fuels, and steepness of the slope.

Figure 5.19 Crown-to-crown heat transfer rates influence crown fire development.

the more firebrands launched into the air, the greater the probability that some of them will ignite a spot fire.

- **Type of firebrands** - For a firebrand to cause a spot fire, it first must travel beyond the flame front or across fireline. It must also still be burning with enough heat energy to ignite the fuel bed. Another factor associated with the various types of firebrands are their aerodynamics. Dense, "chunky" firebrands don't fly very well, and thus will not travel great distances. On the other hand, flatter firebrands will travel some distance carried by the wind.

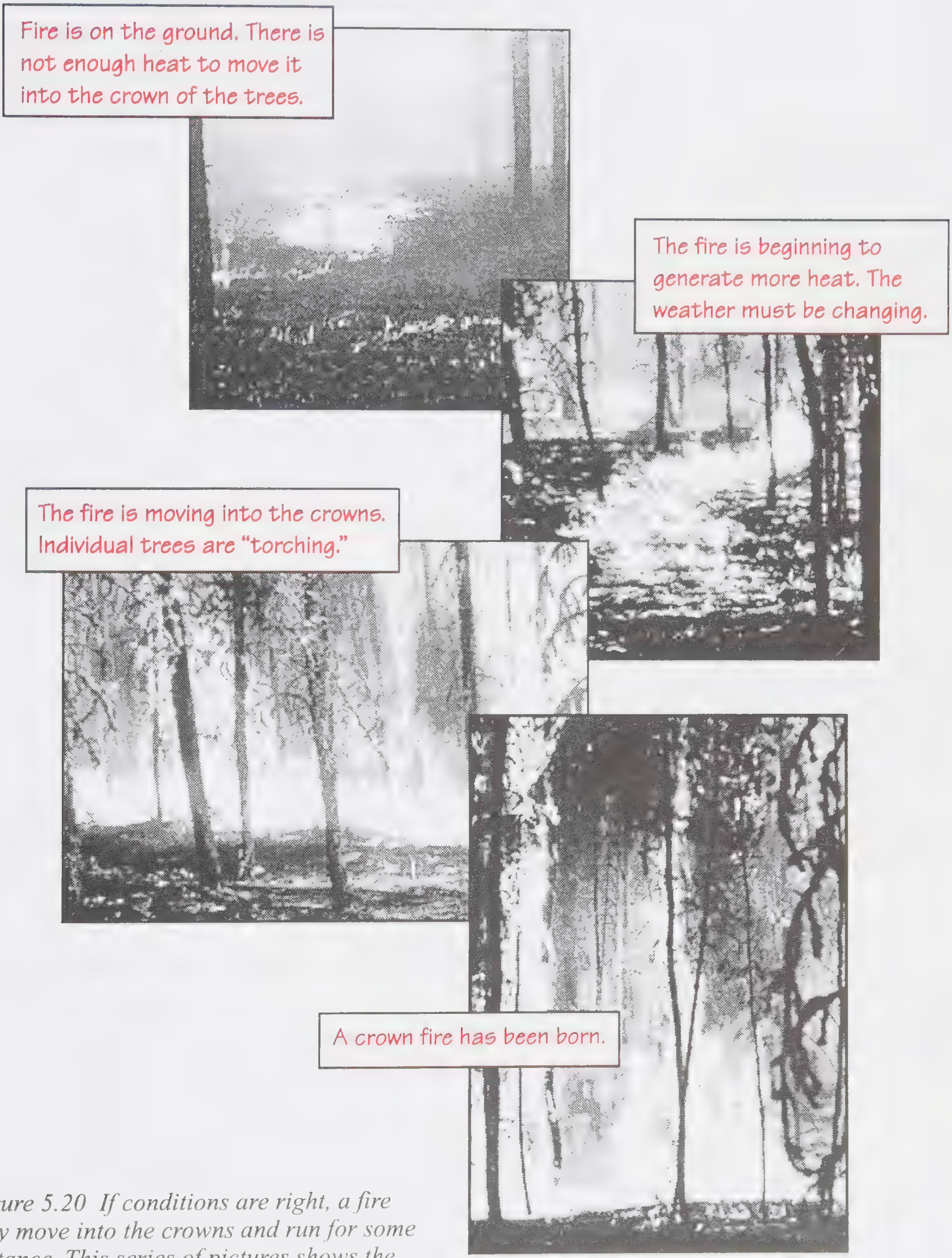
  One of the worst kind of firebrands are those produced by burning shake shingle roofs. These types of firebrands can be large and flat, and can travel great distances.
- **Convective lifting** - The hotter a fire, the more intense the vertical convective action, resulting in a stronger convection column and a higher lift to the firebrands.
- **Wind** - Once a firebrand is lifted into the atmosphere, its travel is controlled by the wind, gravity, and the aerodynamics of the firebrand. Generally, the stronger the wind, the farther the firebrand will travel.
- **Fuel bed** - Firebrands must land on receptive fuels in order for them to ignite. Some examples of receptive fuels are fine, dry fuels, such as litter, duff, rotten wood, and grass.
- **Environmental conditions** - Before a firebrand can start a spot fire, it must not only land in a bed of receptive fuels, but the fuel moisture, wind, and slope must favor fire spread in order for the spot fire to become a problem.

The probability of spotting is directly related to such factors as the intensity of the surface fire, burning conditions, fuel species, and crown spacing.

There are two types of spotting: short-range and long-range. They are characterized not by actual distance, but rather by how they relate to the original fire. Short-range spotting is defined as spotting that is quickly overrun by the main front of a fire. Long-range spotting may contribute to the spread of the fire, but in the same way a new fire would. There is no question that a spot fire 15 miles away from the main fire is the result of long-range

Flat firebrands can travel some distance. Wood shakes produce a flat firebrand.

DEVELOPMENT OF A CROWN FIRE



Fire is on the ground. There is not enough heat to move it into the crown of the trees.

The fire is beginning to generate more heat. The weather must be changing.

The fire is moving into the crowns. Individual trees are "torching."

A crown fire has been born.

Figure 5.20 If conditions are right, a fire may move into the crowns and run for some distance. This series of pictures shows the stages of a crown fire as it moves from a surface fire to a crown fire.

spotting. However, going strictly by our definition, a spot fire at only 50 feet from the main fire that creates a new fire is also defined as long-range spotting. Conversely, a spot fire that is ¼-mile forward of the fire's head, but which is quickly overrun by the fire, is defined as short-range spotting. Long-range spotting can cause you serious problems. Short-range spotting usually does not contribute to the spread of the fire.

The stronger the wind, the farther the firebrand will travel.

Spotting usually occurs downwind. This may not be the same direction that the surface winds are blowing. If the upper-level winds are moving in another direction, the spotting may be downwind in that direction. Also, spot fires do not necessarily "show themselves" right away. They may smolder for hours or even days. Spot fires don't usually travel alone. If there is one spot fire, his buddies may be close by!

There are seven different large fire types which demonstrate different spotting characteristics. Figure 5.21 outlines these characteristics.

Probability of Spotting

The probability of a firebrand starting a fire can be predicted, as you will see shortly. Probability of ignition is the percentage of firebrands "launched" that actually start fires. When the probability of ignition is 70 percent, it means that of ten glowing firebrands that land on receptive fuels, seven of them will, in fact, start a new fire.

Short-range spotting has no real impact on fire spread.

The probability of spotting does not reflect the size or shape of the firebrand, nor the type of available fuels. It only deals with the probability that if firebrands are produced, what percentage will start a new fire.

A Probability of Ignition Table (Figure 5.22) has been developed. The probability is determined by factoring in the fuel shading, fine dead fuel moisture, and dry bulb temperature. The adjective ratings for the probability of ignition are: 91 to 100, extreme; 71 to 90, very high; 51 to 70, high; 31 to 50, moderate; and 0 to 30, low. The probability of ignition rating is used routinely by fire officers, because it gives a good indication of how easily a spot fire may develop in light fuels. Remember! Spotting is one of the situations that shout "watch out!"

Spotting usually occurs downwind. This may not be in the same direction as the surface wind.

Area Ignition

Area ignition occurs when an area is "peppered" with spot fires. The spot fires will begin to interact and affect each other. This can occur in a canyon, valley, or on flat land. As the fires begin to draw each other closer, and their convective actions connect, the area may explode. When this occurs, the fire may not be moving in any one particular direction, but may just take out a large chunk of real estate. In an area ignition, most of the energy release is vertical, not horizontal.

The probability of spotting can be predicted.

Vortices

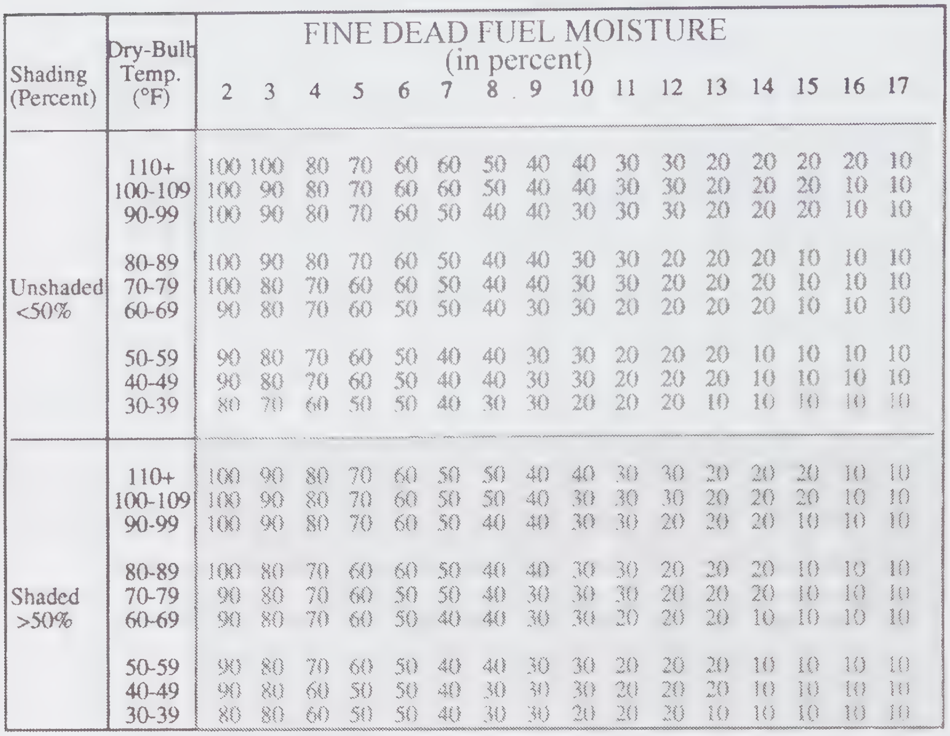
A vortex is defined as a whirling mass of air, with a low-pressure area in its center, that tends to draw fire or other objects into the vortex action (Figure 5.23). The vortex action is strongest at the center. Vortices come in two types: vertical and horizontal. They are formed by a heat source and initiating swirl.

Vertical vortices are called dust devils or whirlwinds. When they include burning material or flame from a fire, they are called fire whirls. Some vertical vortices are initiated by thermal forces. Vortices initiated by thermal forces occur on hot days, or are associated with a wildland fire. Convective-driven vortices are produced by unequal convective activity.

SPOTTING CHARACTERISTICS OF LARGE FIRES

	Large Fire Types	Dominant Feature
I	Towering convection column with light surface winds.	Moderate to rapid fire spread persistent until fire environment changes.
II	Towering convection column over slope.	Rapid, short-term spread with convection cut off at the ridge crest.
III	Strong convection column with strong surface winds.	Rapid rate-of-spread with short-range spotting.
IV	Short, vertical convection column cut off by wind shear.	Steady or rapid fire spread with occasional long-range spotting.
V	Leaning convection column with moderate surface winds.	Rapid spread with both short- and long-range spotting.
VI	No rising convection column under strong surface winds.	Very rapid spread driven by combined fire and wind energy; frequent close spotting.
VII	Mountain topography with strong surface winds.	Rapid spread both up and downslope with frequent spotting and area ignition.

Figure 5.21 The spotting characteristics of the seven different large fire types.



PROBABILITY OF IGNITION TABLE

Shading (Percent)	Dry-Bulb Temp. (°F)	FINE DEAD FUEL MOISTURE (in percent)															
		2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Unshaded <50%	110+	100	100	80	70	60	60	50	40	40	30	30	20	20	20	20	10
	100-109	100	90	80	70	60	60	50	40	40	30	30	20	20	20	10	10
	90-99	100	90	80	70	60	50	40	40	30	30	30	20	20	20	10	10
	80-89	100	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10
	70-79	100	80	70	60	60	50	40	40	30	30	20	20	20	10	10	10
	60-69	90	80	70	60	50	50	40	30	30	20	20	20	20	10	10	10
	50-59	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10	10
	40-49	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10	10
	30-39	80	70	60	50	50	40	30	30	20	20	20	10	10	10	10	10
Shaded >50%	110+	100	90	80	70	60	50	50	40	40	30	30	20	20	20	10	10
	100-109	100	90	80	70	60	50	50	40	30	30	30	20	20	20	10	10
	90-99	100	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10
	80-89	100	80	70	60	60	50	40	40	30	30	20	20	20	10	10	10
	70-79	90	80	70	60	50	50	40	30	30	30	20	20	20	10	10	10
	60-69	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10	10
	50-59	90	80	70	60	50	40	40	30	30	20	20	20	10	10	10	10
	40-49	90	80	60	50	50	40	30	30	30	20	20	20	10	10	10	10
	30-39	80	80	60	50	50	40	30	30	20	20	20	10	10	10	10	10

Figure 5.22 The Probability of Ignition Table. If you have a fuel bed that is unshaded, a dry-bulb temperature of 85°, and a fine fuel moisture of 6%, the probability of an ignition is 60 percent.

Wake-driven vortices occur on the lee sides of physical objects like ridge tops, trees, or convection columns, as the wind passes by these objects.

Horizontal vortices are a phenomenon of extreme burning conditions (Figure 5.24). There are two kinds of horizontal vortices: those that occur on the surface along the flanks of a wildland fire, and those that occur in the convection column. The ones on the fireline are dangerous to line personnel. Those that occur in the atmosphere can disrupt air operations.

The development of vortices can occur along the flanks of a rapidly developing wildland fire, when there is extreme fire behavior, low to moderate winds, and flat or rolling terrain. They can occur over large enough areas to trap whole crews.

It is not uncommon for the winds at the center of a vortex to exceed 100 miles per hour. They are hard to predict, but some areas are more prone to their development than others. If you have seen them in the area before, be on the lookout for them to develop again.

> *NOTE: A low-flying heavy airtanker may produce a horizontal vortex, and helicopter rotor wash may produce a vertical vortex; either can adversely affect your fireline.*

Figure 5.23 This is a vortex or dust devil. When full of fire, the vortex is called a fire whirl.

Extreme Fire Behavior Patterns

Wildland fires that are demonstrating extreme fire behavior can be classified as wind-driven or plume-driven, depending on which force is strongest. In a wind-driven fire, the power of the wind is dominant; in a plume-driven fire, the forces that are developing the plume or convection column are dominant.

Wind-Driven Fires

Most fires that become large are driven by a wind, and are classified as wind-driven. With a wind-driven fire, you usually have an idea what direction it will burn in. The smoke (convection) column is pushed over by the wind, driving the heat into the unburned fuels (Figure 5.25). Spotting is normally downwind, and is a major contributor to the spread of

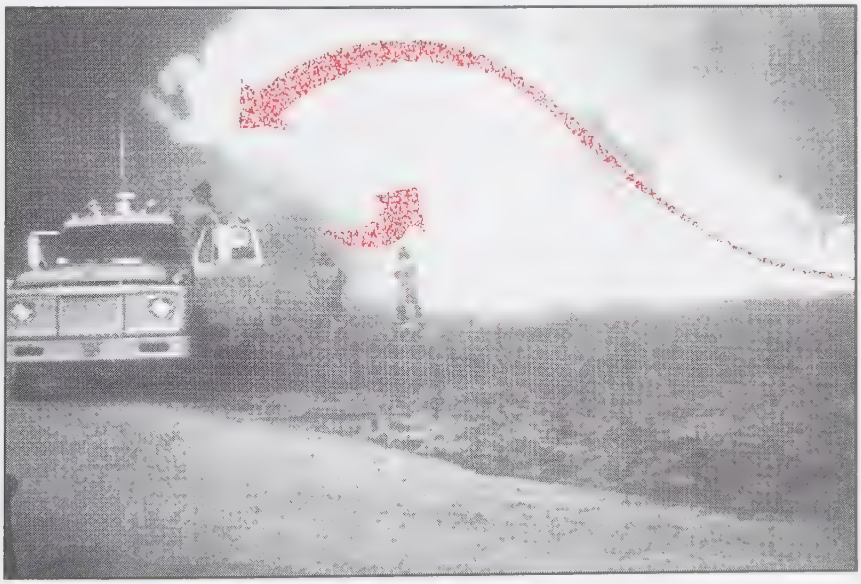


Figure 5.24 A horizontal vortex is about to carry the fire across this fireline. This type of event is driven by extreme fire behavior.

There are two kinds of vortices: horizontal and vertical.

the fire. This spotting can occur miles ahead of the main fire. A crown fire is very likely. A wind-driven fire may become a plume-driven fire, when the energy released by the fire takes the convective column to such heights that its force becomes greater than the wind.

A low-flying aircraft can produce a horizontal vortex.

Whenever you have a wind-driven fire:

- The rate-of-spread is rapid.
- There is long-range spotting.
- The direction of spread is predictable.
- The flanks of the fire may be safe to attack.
- Wind shifts should be a major concern.

Plume-Driven Fires

The convection column and the forces that develop it are the dominating forces on this type of event. The direction of travel and the rate-of-spread are harder to predict. Spotting usually does not occur at great distances, but can occur in any direction.

Whenever you have a plume-driven fire:

- There can be a sudden increase in fire intensity.
- Spotting occurs in all directions.
- The direction of spread is difficult to predict.
- Downdrafts should be a major concern.

There are two types of wind events that can accompany a plume-driven fire: indrafts and downdrafts. **Indraft** winds move

The wind is the dominant force in wind-driven fires.

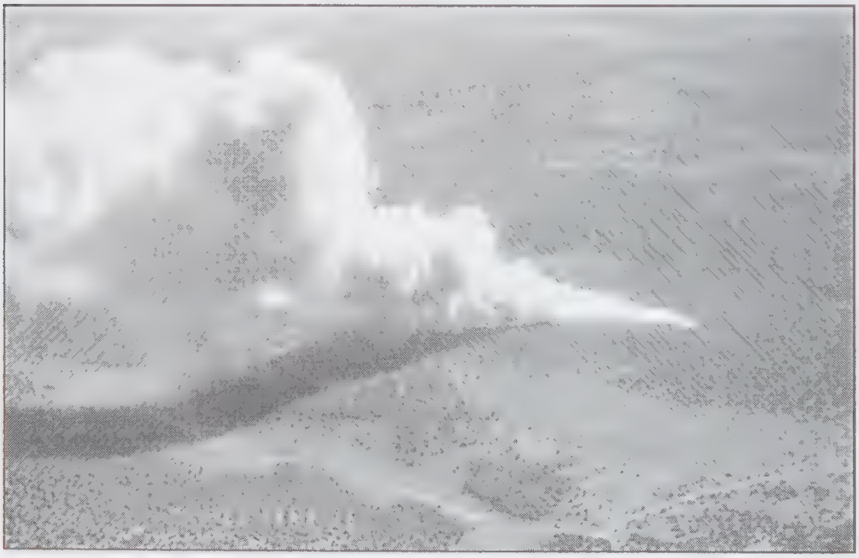


Figure 5.25 This is a wind-driven fire. Note how the smoke column is pushed over and held close to the surface by the wind.

in to replace heated air that is lifted by the convective action of the fire. Indrafts provide oxygen to the flame front, increasing convective heating and preheating the fuels. This creates a "cycle of reinforcement," where the increases in the wind increase the intensity of the fire, which in turn further increases the wind.

Downdrafts occur below the convective column. When the heated air is lifted by the convection column, and subsequently cooled in the upper atmosphere (by the effect of lapse rate or evaporation of rain), it rushes back toward the surface of the earth. When it hits the ground, the wind spreads in all directions, causing real havoc for firefighters.

If you are working on a plume-driven fire, and you begin to see virga and/or rain, downdrafts may be developing. The indraft winds usually drop off just before the downdraft hits. Survivors of fatal fires have reported feeling light rain and cool air and a short period of calm just before the fire exploded.

The convection column is the dominant force in a plume-driven fire.

Extreme Fire Behavior Situations

The best teacher is experience. The second best is learning from others. Over the years there have been fires that are legends: fires named Mann Gulch, Sundance, and Loop. More recent fires that will join these are Tunnel, South Canyon, and Point.

In this section, several major fires will be discussed from the fire officer's point of view. These fires were selected not because they killed or injured firefighters, but because they have been analyzed more than most other fires, so good data or pictures exist.

Indraft winds move in to replace heated air that is lifted by the convective action of a fire.

The review of these fires will include a scenario and analysis of the events that led up to the significant event, what indicators were present, and what you as the officer in charge might have done to change the outcome. They say "hindsight is always 20-20." It is not the intent here to criticize or imply blame in these situations. But we can attempt to learn from these events, as well as any mistakes that were made, so that we can minimize the chances of future disasters.

Downdrafts occur when heated air is cooled in the upper atmosphere and it rushes back to earth.

Butte Fire

Salmon National Forest
USDA Forest Service
Idaho

The Butte fire of August 1985 did not kill anyone, but it did show how strong leadership and proper use of fire shelters can save lives. On the afternoon of August 29, 1985, 73 firefighters were overrun and trapped by a crown fire in the Salmon National Forest of Idaho.

Background

We can always learn from the critiques of major fires.

The Butte fire was one of several fires that were started by lightning on July 20, 1985, along the Salmon River. The Butte fire was contained on August 5, at about 20,000 acres. However, on August 24 and 25, strong winds fanned smoldering spot fires outside firelines.

> ***WEATHER***: *The weather in the area was not unusual for late August. Late afternoon temperatures were between 70° to 78°, with minimum relative humidities in the 12 to 21 percent range. The windiest period each day occurred between 1400 and 1500 hours, with speeds generally 10 to 12 miles per hour. Inversions occurred each day, breaking down between 1130 and 1330 hours.*

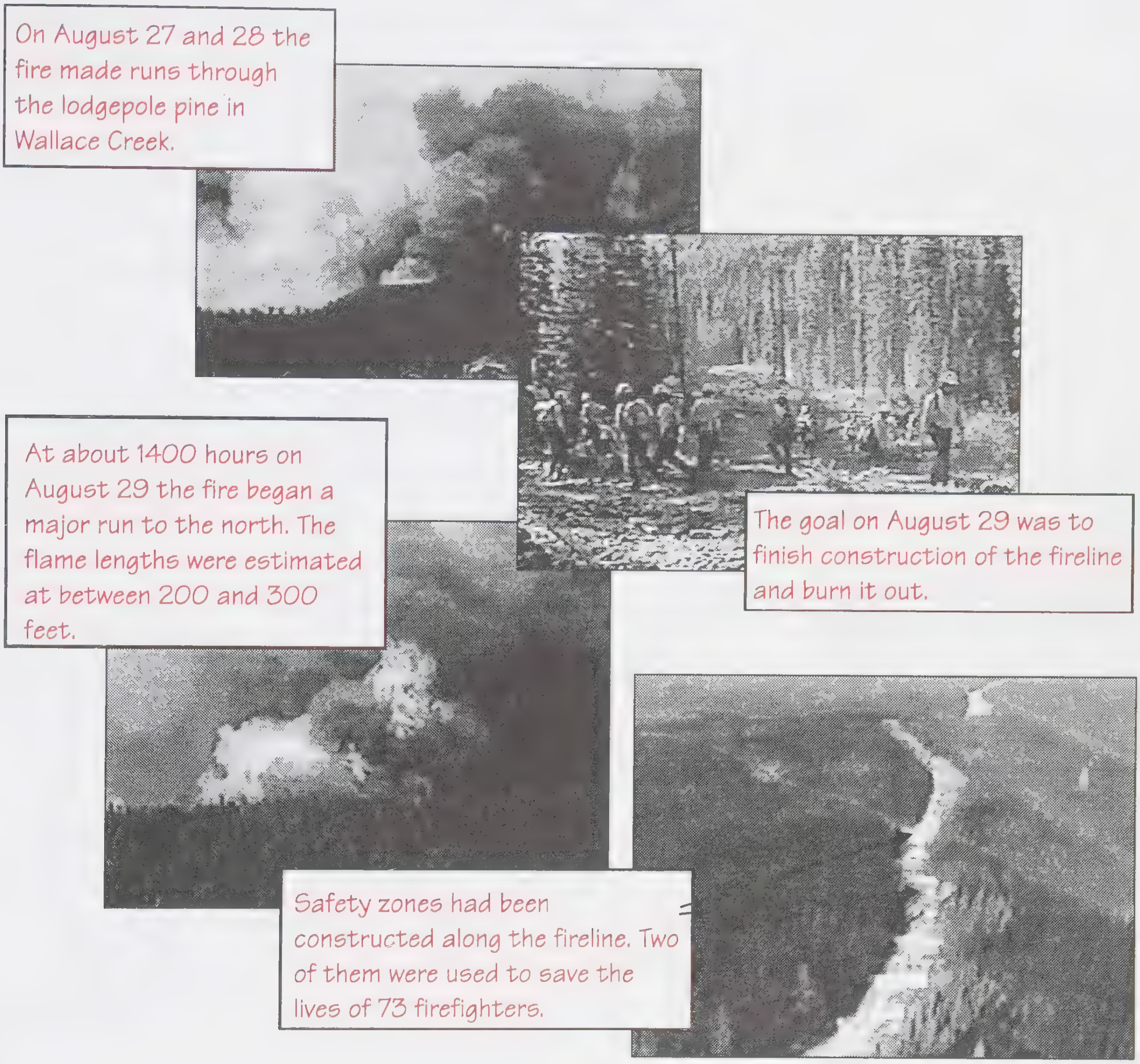
August 27 and 28 - Fire behavior was increasing. Several runs consumed about 1,000 acres on the 27th, and 2,000 acres on the 28th. Line was being constructed around all of the Wallace Creek drainage (Figure 5.26).

73 firefighters were saved by the proper use of their fire shelters.

August 29 - The fire did not cool down during the night. Between 2200 hours and 0200 hours, the fire was active all along the north and west flanks (Figure 5.27). This would indicate that there was little if any relative humidity recovery during the night. Early in the morning, several large spot fires were detected in the Wallace Creek drainage.

The plan for the day was to burn out the rim of Wallace Creek starting from a point along the fireline that had been constructed with bulldozers. A helitorch would be used to spread fire

BUTTE FIRE



On August 27 and 28 the fire made runs through the lodgepole pine in Wallace Creek.

At about 1400 hours on August 29 the fire began a major run to the north. The flame lengths were estimated at between 200 and 300 feet.

The goal on August 29 was to finish construction of the fireline and burn it out.

Safety zones had been constructed along the fireline. Two of them were used to save the lives of 73 firefighters.

Figure 5.26 Fireline was constructed by bulldozers around Wallace Creek drainage. The plan was to fire this line on August 29. Safety zones were constructed every ¼-mile along the ridge.

some distance from the fireline. Once this operation had developed a convection column, the fireline would be fired by handcrews.

Around noon, the fire started moving up into the Owl Creek area, threatening to outflank placement of control lines. The helitorch was used again to fire out several areas in an attempt to slow the fire's movement (Figure 5.28).

Bulldozers were used to construct fireline 2 miles ahead of the fire.

1430 hours - The fire had moved another ¾-mile in the previous 12 hours. It was still moving to the north, up Wallace Creek. All of the fires in the complex were heating up and starting to run. Personnel, who were taking weather readings on the fireline, noticed that the relative humidity had dropped to about 20%. This was their signal that it was time to move toward safety. Crews moved into three areas: the lower deployment site, the Tin Cup Hill site, and a large clear-cut area on the northeast corner of the fire.

1515 hours - Fire was now active all along the fireline. It was moving up Wallace Creek and Owl Creek. There was also fire moving in the area of Dishpan Springs. The firefighters were getting ready for the fire to overrun the two safety zones and the clear-cut area. The 73 firefighters in the lower and Tin Cup Hill safety zones deployed their shelters. The firefighters in the large clear-cut area did not have to use their shelters.

The weather on the fire was not unusual.

> ***WEATHER**: The weather was basically the same as the past several days: temperatures in the mid-70s, relative humidities in the teens, and winds from the south at 8 to 12 miles per hour.*

Conditions were developing into a scenario with the potential for extreme danger. The south-facing slopes were at their peak flammability; the general winds were from the south; the up-canyon winds were active; and the slope was increasing to an average of 45 percent. **Everything was ripe for a major run right at the firefighters on the ridge**.

1600 hours - The fire was now on Tin Cup Hill, the upper safety zone, and the clear-cut area. Ten minutes later the fire crossed the fireline at the lower safety zone. As the fire approached each of the safety zones, firefighters did some firing out in an attempt to create some black area. Tin Cup Hill was hit by three separate waves of fire, each from different directions. This forced the firefighters, still in their shelters, to move around the safety zone, away from the new waves of fire.

A helitorch was used to try to protect valuable timber.

The firefighters reported later that there were periods of very intense heat inside the shelters, but smoke did not infiltrate the

BUTTE FIRE PRIOR TO MAJOR FIRE RUN OF AUGUST 29

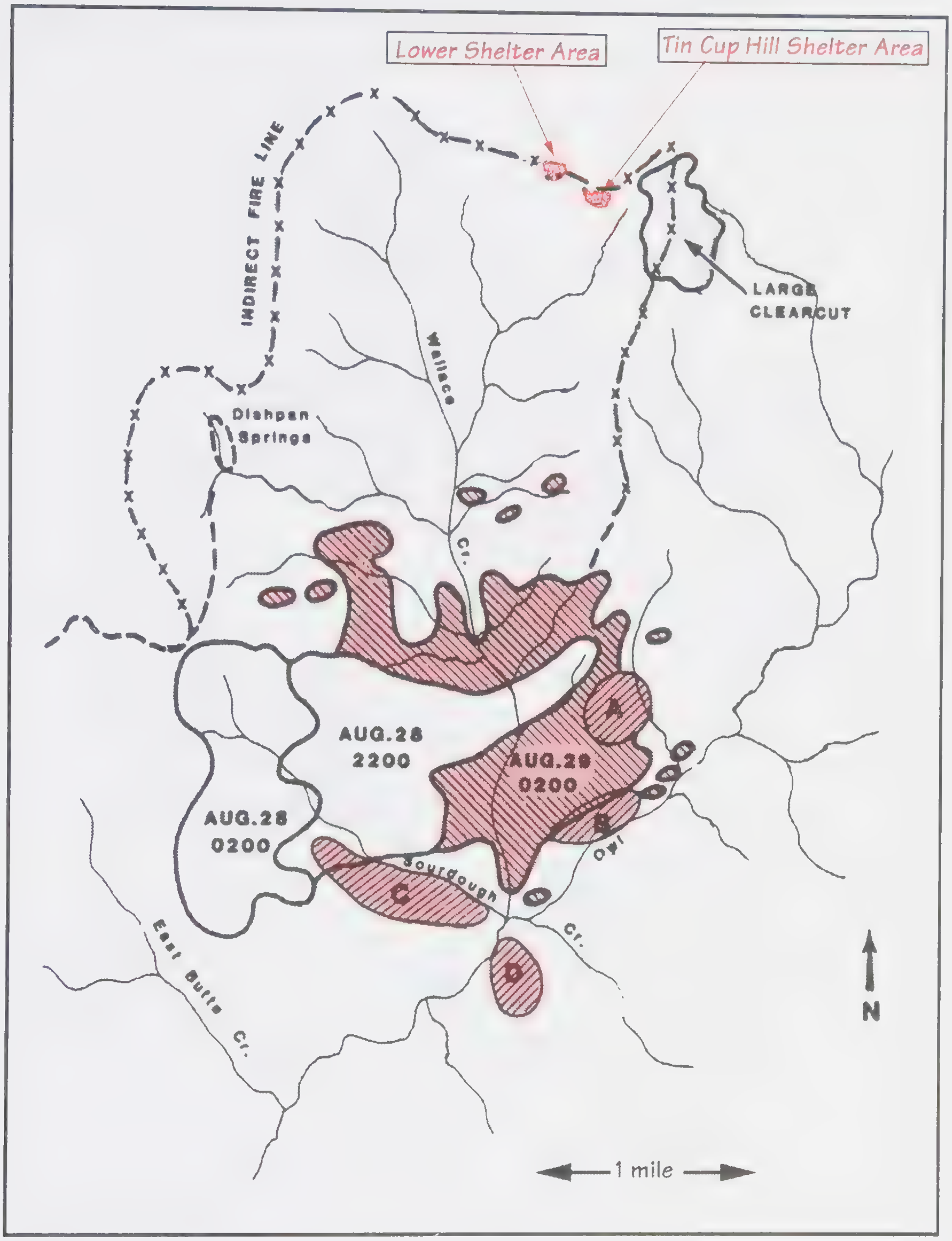

Lower Shelter Area
Tin Cup Hill Shelter Area
INDIRECT FIRE LINE
LARGE CLEARCUT
Dishpan Springs
Wallace Cr.
AUG.28 2200
AUG.29 0200
AUG.28 0200
A
B
C
D
Sourdough Cr.
Owl
East Butte Cr.
N
1 mile

Figure 5.27 The fire was active, burning over 1,000 acres by 0200 hours on August 29. During the afternoon of August 29, a helitorch was used to set fire in the Owl Creek drainage in an attempt to save valuable timber (Points A, B, C, and D).

shelters as much as expected. Several of the firefighters also reported that the noise of the fire, and the shaking of the ground was the most frightening part of the whole ordeal.

The firefighters were getting ready to deploy their shelters.

BUTTE FIRE MAJOR FIRE RUN ON
THE AFTERNOON OF AUGUST 29

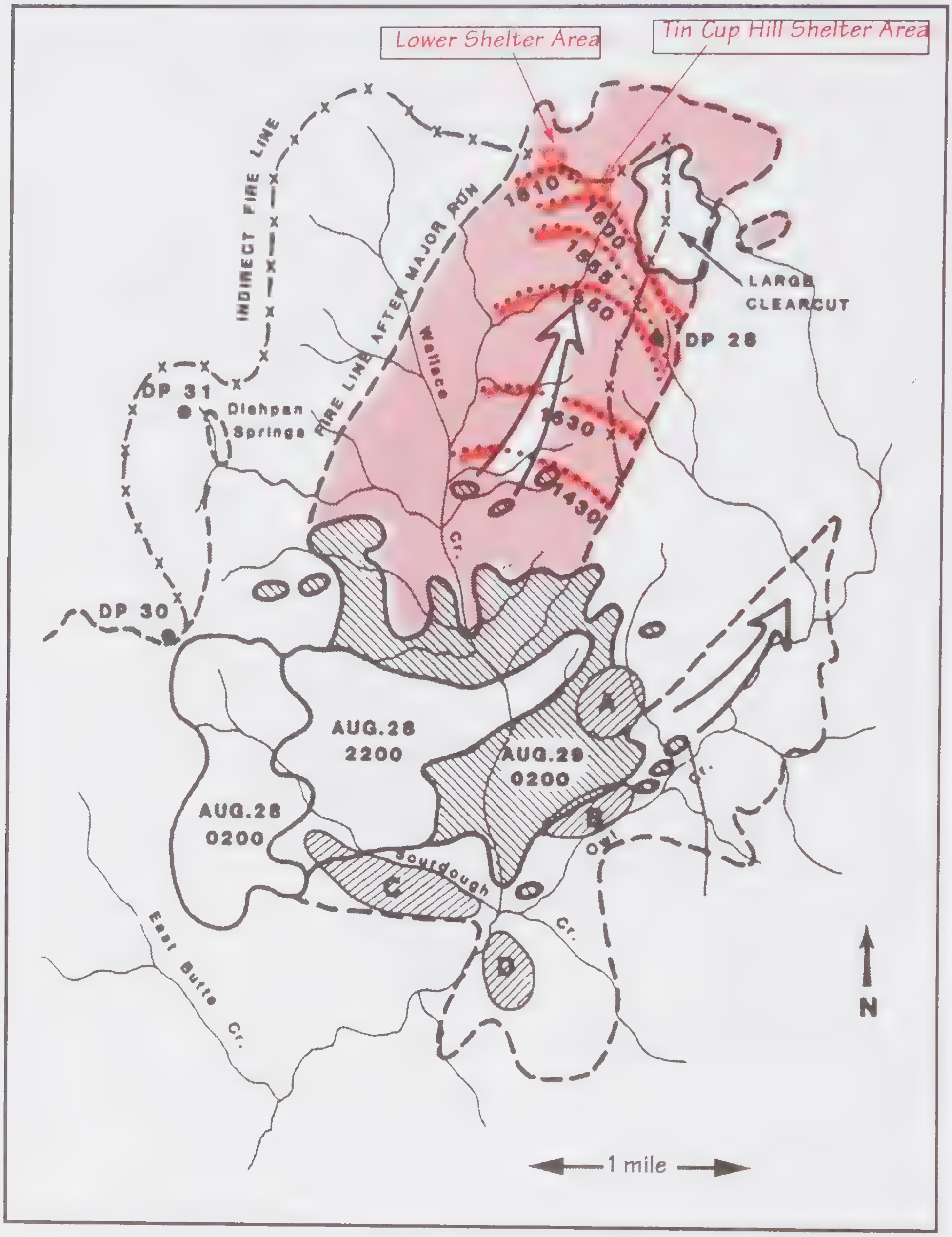

Lower Shelter Area
Tin Cup Hill Shelter Area
INDIRECT FIRE LINE
FIRE LINE AFTER MAJOR RUN
1610
1600
1555
1550
1530
1430
LARGE CLEARCUT
DP 28
DP 31
Dishpan Springs
DP 30
Wallace Cr.
AUG.28 2200
AUG.29 0200
AUG.28 0200
A
B
C
D
Sourdough Cr.
East Butte Cr.
N
1 mile

Figure 5.28 At about 1430 hours, the fire started a major run toward the north. At 1610 hours, the fire crossed the ridge and fireline. 73 firefighters were in their fire shelters when it crossed the line. None of them were killed.

Only five of the 73 firefighters who deployed shelters that afternoon required hospitalization. They all recovered. It was the general consensus of those who deployed their shelters that without the shelters, none of them would have survived.

Critique

Several key actions allowed this potentially disastrous event to end up without any serious injuries. By all accounts, if these firefighters had attempted to escape the fire, and shelters were not available, this would have been one of the worst catastrophes on record.

So what led to the success of this deployment?

- The firefighters were well-trained and self-disciplined.
- All of the leaders on this section of line had control of the situation and their personnel.
- All of the people involved had fire shelters.
- The fire's progress was monitored, and the changing weather influences were tracked.
- The safety zones were large enough to provide protection for personnel inside a shelter.

Note: The use of the term safety zones is not really accurate in this instance. A safety zone is defined as a place firefighters can safely stay, without the use of shelters. By that definition, the two designated areas where the shelters were deployed were not truly safety zones. However, the areas did contribute to the survival with minimal injury, because they were free of heavy fuels, were identified in advance, and were easily reachable.

In hindsight, the incident management team could have prevented the need for shelters by constructing larger safety zones, or moving the firefighters from this section of the line earlier. The construction of larger safety zones was possible, but probably not practical, under the fire/weather conditions they were expecting. The crews on the fireline were tracking the weather. They had decided in advance to move off the line, when the relative humidity dropped to 20%, and they did move based on that cue. The last option available to the command team may have been to "time tag" the movement of the forces. In other words, all forces could have withdrawn from the area at a specific time, like 1500 hours, when the area was receiving the greatest amount of solar radiation and the normal upslope winds could be expected to influence the fire. But, the key to the success of this shelter deployment was that the crews were well disciplined, and they had already identified locations they could quickly withdraw to and seek shelter.

The firefighters moved around the safety zone as three separate waves of heat, from three different directions hit them.

The noise of the fire and the shaking of the ground was very frightening.

The crew leaders had a plan and the well-trained firefighters followed it.

Point Fire

Boise District
USDI Bureau of Land Management
Idaho

The Point fire was started by lightning on July 28, 1995, in the sage brush south of Boise, Idaho. It was contained by forces within an hour, but the passage of a cold front blew the fire across firelines, catching and killing two local government firefighters.

Background

The decision had been made earlier in the day, that when the relative humidity dropped to 20%, they would move to the safety zones.

The 1995 fire season in the Boise, Idaho area was about normal. The previous winter had above-normal rainfall. This allowed for the abundant growth of cheatgrass. The weather pattern the two weeks leading up to the fire was typical for the area. The temperatures ranged from the upper 80s to high 90s; relative humidities were in the low to mid-teens. The 10-hour fuels in the area were at 4% on the day of the incident.

> ***WEATHER****: At 0900 hours, July 28, 1995, the fire weather forecast for the Boise area included a fire weather watch for dry lightning.*

The Point fire was one of several fires started by thunderstorms on July 28, 1995. The fire was first reported at 1829 hours by a lookout. It was reported to be about 16 miles southwest of Boise. Two minutes later, the dispatch center for the Boise District of the Bureau of Land Management dispatched two Type 4 engines, one Type 6 engine, and an incident commander. This dispatch was augmented a short time later with three more Type 4 engines, one Type 2 water tender, a bulldozer unit, and one more overhead. At 1857 hours the Boise helicopter and crew were dispatched to the fire.

The winds from a passing cold front can kill.

The first units arrived at about 1900 hours. They estimated the fire to be 60 to 65 acres, with a moderate rate-of-spread in 3 to 4-foot sagebrush and cheatgrass, and burning with 3 to 5-foot flame lengths. The initial attack forces began flanking the fire from the origin northeast toward Swan Falls Road (Figure 5.29).

The BLM Type 6 engine was instructed to attempt to hold the fire west of Swan Falls Road.

> ***WEATHER****: The winds were estimated to be from the west at 4 to 6 miles per hour as the initial attack was begun.*

Dry lightning started a series of fires.

1905 hours - The local fire agency asked if the Bureau needed assistance. The IC indicated he could use help. Two minutes later three units (one engine with 1,500 gallons of water; another engine with 1,750 gallons of water; and a 2,500 gallon water tender) from the Kuna Rural Fire Department were dispatched. The task force leader (known as "Kuna Command") traveled to the fire aboard one of the units.

1915 hours - The helicopter arrived at the fire and the IC took a reconnaissance flight. The helicopter was released to another fire at 1937 hours. The Kuna Fire Chief, via the radio, instructed the firefighters assigned to the two Kuna engines (E620 and E622) to stay together.

1927 hours - The second element of BLM's initial attack arrived at the fire. Two of the engines were assigned to the north flank, and the third engine was assigned to the south flank. The leader of this element of resources remained on Swan Falls Road (Figure 5.30).

Three engines started a flanking action. The flames were 3 to 5-feet in length.

1930 hours - The three units from the Kuna Fire Department arrived at the fire. The Kuna water tender was positioned on the road. "Kuna Command" stayed with the water tender; he was going to use the water tender as his command post. The two Kuna engines (E620 and E622) were assigned to the north flank. The bulldozer arrived and began constructing fireline from the origin along the south flank toward Swan Falls Road.

2010 hours - The IC reported that the spread of the fire had been stopped at about 120 acres.

Local government forces were requested.

> ***WEATHER****: At about 2020 hours an updated fire weather forecast was issued posting a red flag warning for dry lightning and locally strong winds. The Boise radar had detected a line of thunderstorms in the Boise area. The area could expect gusting winds to 50 miles per hour. The storm was moving northeast at 30 miles per hour.*

One of the BLM engines stayed on the road to prevent the fire from crossing it.

The terrain was very flat. The wind was from the southwest.

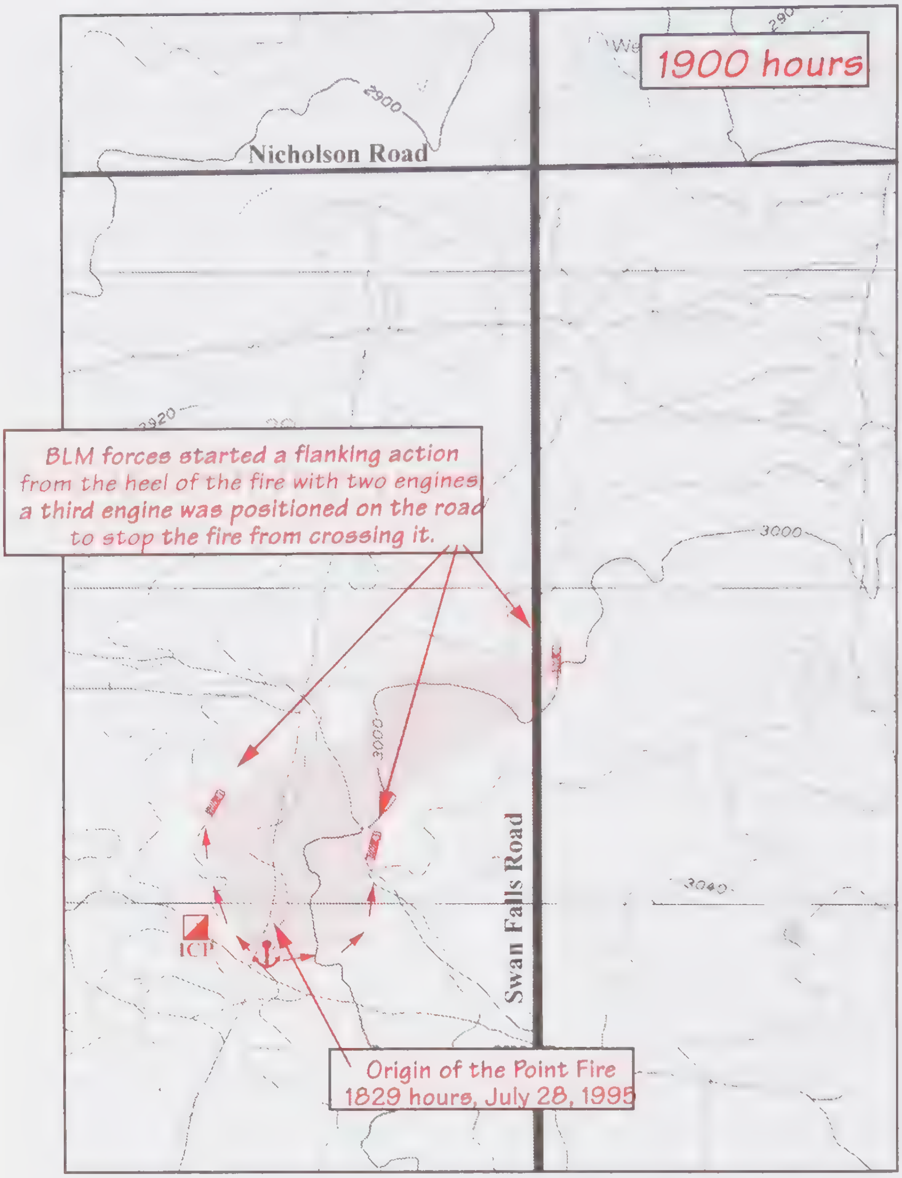
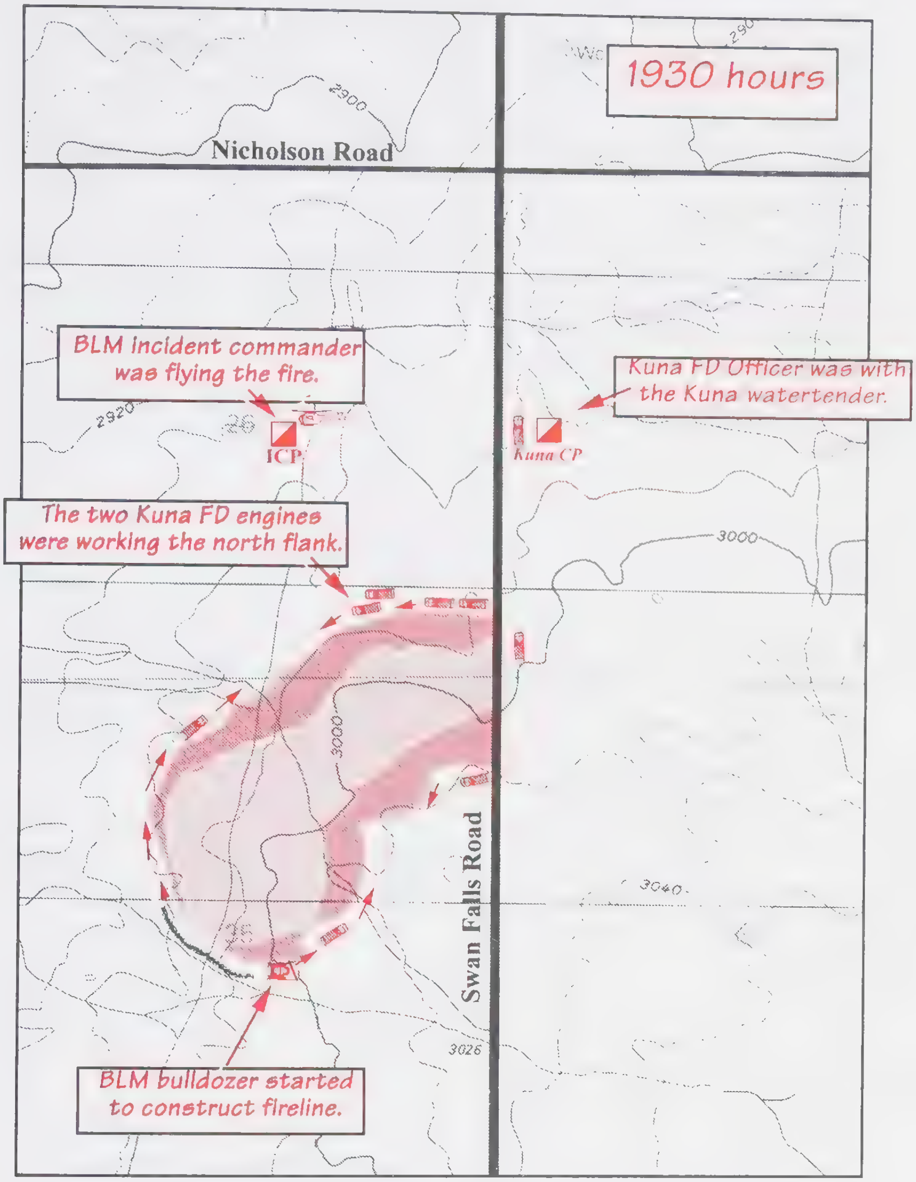

1900 hours
2900
Nicholson Road
2920
BLM forces started a flanking action from the heel of the fire with two engines a third engine was positioned on the road to stop the fire from crossing it.
3000
3000
Swan Falls Road
3040
ICP
Origin of the Point Fire
1829 hours, July 28, 1995

Figure 5.29 The initial attack began about 30 minutes after the fire was first reported. The two BLM engines began flanking the fire from the origin.

2022 hours - The red flag warning was transmitted to the IC. He acknowledged and began plans to reinforce the northern flank.

The two Kuna engines were working the perimeter of the fire. They moved west along the north flank. They continued to work their way along the south flank to the east until they passed the bulldozer. The two units were then instructed to reverse course and work their way back to the north flank. Just as they got back



1930 hours

BLM Incident commander was flying the fire.

Kuna FD Officer was with the Kuna watertender.

The two Kuna FD engines were working the north flank.

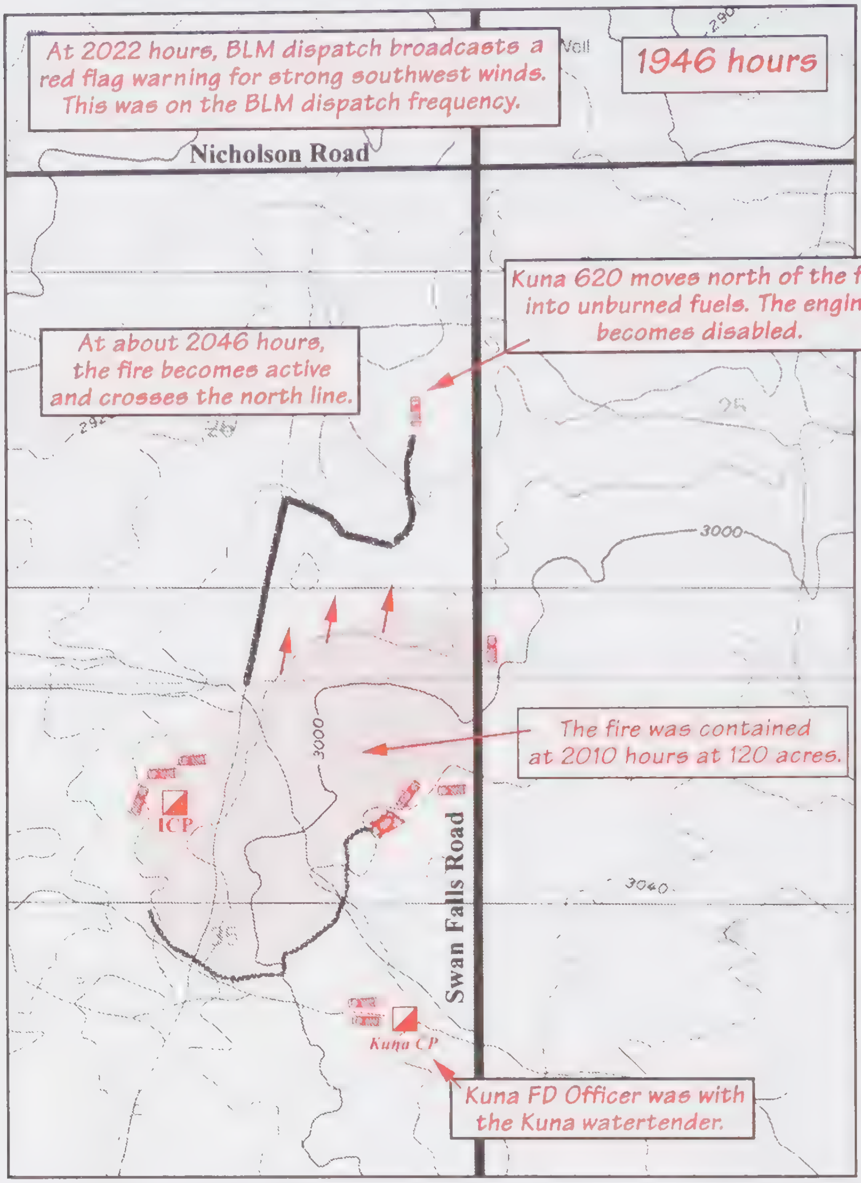
BLM bulldozer started to construct fireline.

Figure 5.30 *The next arriving units were deployed on the fire.*

The Kuna FD officer was without his own vehicle, so he stayed on the road with the water tender.

The IC and the Kuna FD Officer never established one ICP.

to the north flank, Kuna E622 ran out of water. The crew was instructed to refill and stand by because of the possibility of high winds. Kuna E620 did not stay with the empty unit (as they were instructed earlier) but continued to work the north flank. As Kuna E622 got to the road, Kuna E620 reported that the unit was overheating. For some unknown reason, Kuna E620 had moved into the "green" about ¼-mile north of the north flank (Figure 5.31).



1946 hours

At 2022 hours, BLM dispatch broadcasts a red flag warning for strong southwest winds. This was on the BLM dispatch frequency.

Kuna 620 moves north of the fire into unburned fuels. The engine becomes disabled.

At about 2046 hours, the fire becomes active and crosses the north line.

The fire was contained at 2010 hours at 120 acres.

Kuna FD Officer was with the Kuna watertender.

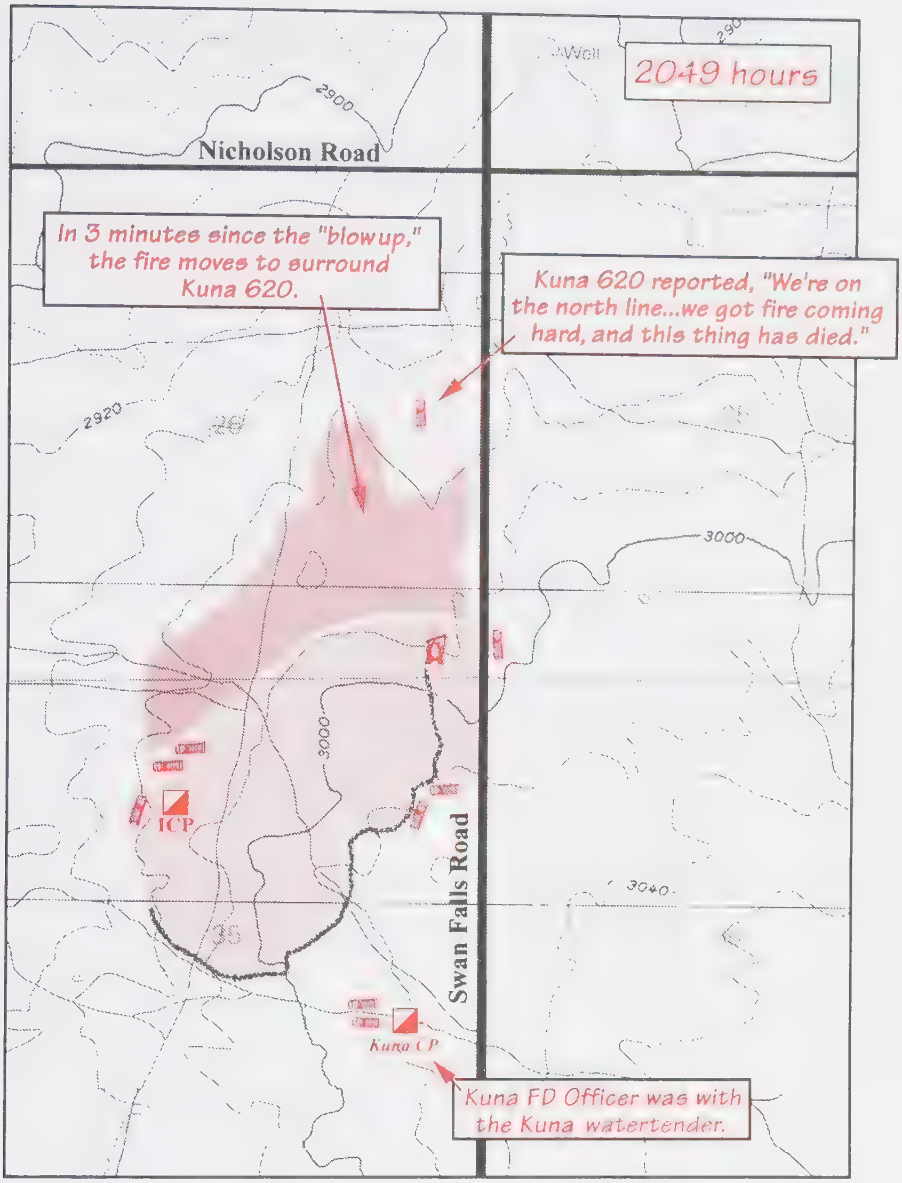
Figure 5.31 For some unknown reason, Kuna E620 moved into the "green." The unit reported that it was overheating.

2046 hours - The line of thunderstorms approached the fire, and strong winds blew the fire across the line in several places.

2049 hours - Kuna E620 reported, "We're on the north line. We've got fire coming hard, and this thing has died." A minute later they reported, "It's not going to let us out of here!" They then reported that they were being overrun by the fire (Figure 5.32 and 5.33).

A red flag warning was issued for locally strong winds.

Personnel on Swan Falls Road saw the Kuna unit in the green, but couldn't do anything to assist them. The fire behavior



2049 hours

In 3 minutes since the "blowup," the fire moves to surround Kuna 620.

Kuna 620 reported, "We're on the north line...we got fire coming hard, and this thing has died."

Kuna FD Officer was with the Kuna watertender.

Figure 5.32 Kuna E620 stalled; the fire was running hard toward them.

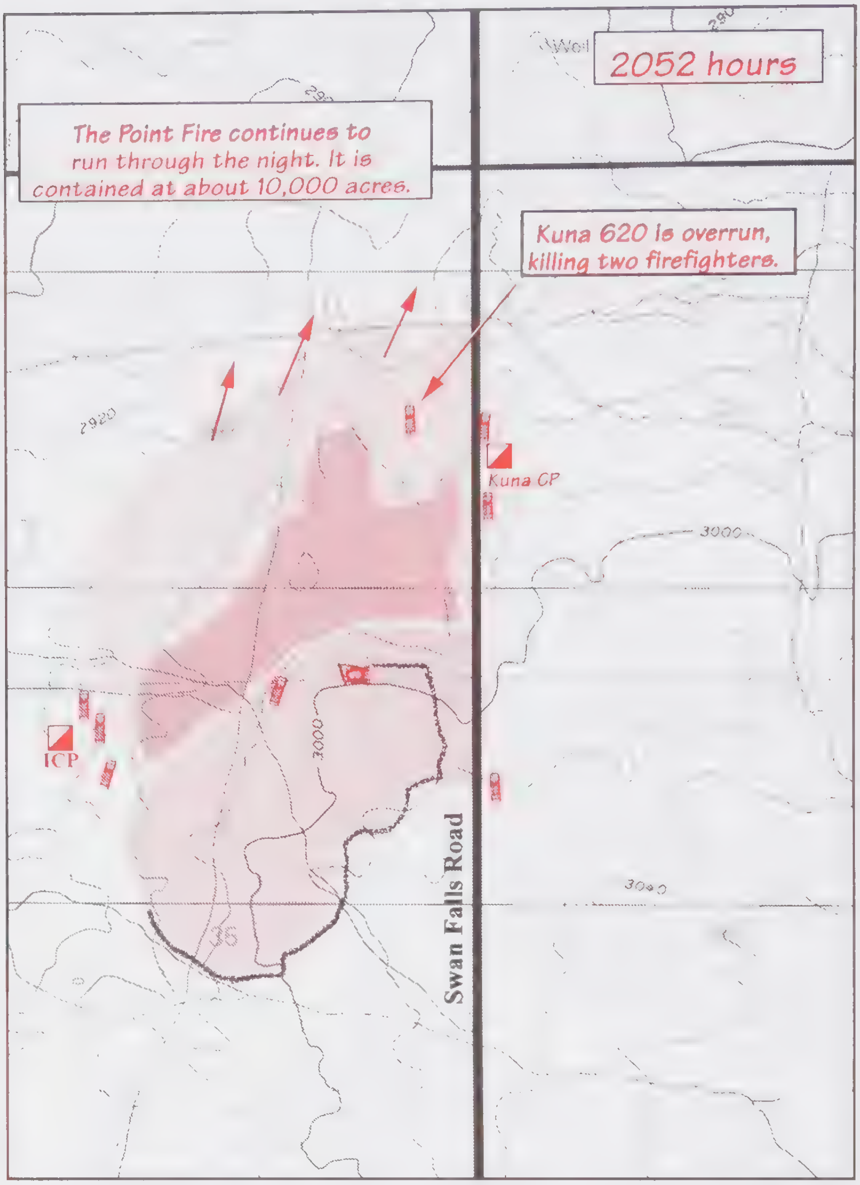
Kuna 620 stalled in the green as the fire headed toward them.

Nothing could be done to rescue them.

was extreme. Flame lengths were estimated at 20 feet with a fast rate-of-spread. It took about 4 minutes from the time the fire escaped to the point the engine was overrun. Two Kuna Rural Fire Department firefighters were killed.

The fire then moved off to the northeast, burning about 10,000 acres before it was controlled.

Four minutes after the winds pushed the fire across firelines, the engine was engulfed in fire.



2052 hours

The Point Fire continues to run through the night. It is contained at about 10,000 acres.

Kuna 620 is overrun, killing two firefighters.

The fire burned 10,000 acres before it was controlled.

Figure 5.33 In less than 4 minutes, the fire overran Kuna E620, killing the two firefighters.

Critique

Several factors contributed to this tragedy:

- For some unknown reason, Kuna E620 left the fireline and moved into the unburned area north of the fire.
- The unit overheated and stalled, leaving the two firefighters with no quick way out of the area.
- The fire, being pushed by a south wind of 40 to 50 miles per hour, spotted across containment lines and overran the disabled engine.
- There was no single communications frequency for all units. Not everyone was aware of the red flag warning.

Why Kuna E620 ventured into the green will never be known.

- The BLM incident commander and the fire officer from Kuna did not join up and remain together, and did not have a common communications frequency.

There was no single communication frequency for all the units.

Up until the special red flag warning was issued, this was a routine fire. It had been contained by initial attack forces at about 120 acres. The firefighting resources were actively fighting fire. Good progress was being made on reinforcing the fireline.

The firefighters assigned to Kuna E620 were wearing turnouts provided for structure firefighting, not wildland fire protective clothing. This probably provided some protection, but would have slowed them down if they tried to run. Neither of them had fire shelters.

The IC did not establish an incident command post.

Contrary to instructions given earlier in the evening, Kuna E620 did not follow Kuna E622 back to the road when they left to refill. Kuna E622 moved back to the road based on instructions from the IC (who wasn't aware that the two Kuna units had previously been instructed to stay together).

What would you do?

You are now the IC assigned to this fire. What questions should you ask yourself as you develop your plan, strategies, and tactics?

- Based on the fire season to date and the fire behavior you see when you arrive at the fire, what will your objectives be and how will you attack the fire?
- With local government forces assigned to the fire, how will you fit them into your organization?
- How will you communicate with them?
- What safety issues concern you?
- How do you deal with personnel from another fire department who don't have the training or protective gear they should?
- Once the red flag warning was received, how would you have directed the forces?

Contrary to instructions, the two Kuna units split up.

The objectives for this fire would probably be something like this:

- *Keep the fire west of Swan Falls Road.*
- *Keep the fire south of Nicholson Road.*

What would be your suppression objectives?

You would probably select the same strategy of a direct attack, using wet line followed up with the bulldozer.

You would want to ensure contact with "Kuna Command." The best way to do this would be to remain together at a joint incident command post. This would ensure communications and coordination. You would also conduct a radio check with every unit assigned to the fire, making sure that they knew the wind shift was imminent and to stay in the black or other safety zone.

South Canyon Fire

Grand Junction District
USDI, Bureau of Land Management
Colorado

14 firefighters died in Colorado.

The South Canyon fire of July 1994, is one of the most analyzed fires in the history of wildland firefighting, because it resulted in the tragic death of 14 firefighters.

Background

1994 was not a normal fire year in the area. June had been hotter than normal. The Palmer Drought Index for the area was between -7.3 and -4.1, an extreme drought condition. The area had received less than 60 percent of normal rainfall. The number of fires was double normal levels, and the fires were much larger than normal.

July 2 - The South Canyon fire was one of 40 lightning fires started on the evening of July 2, 1994, in the Grand Junction District of the Bureau of Land Management.

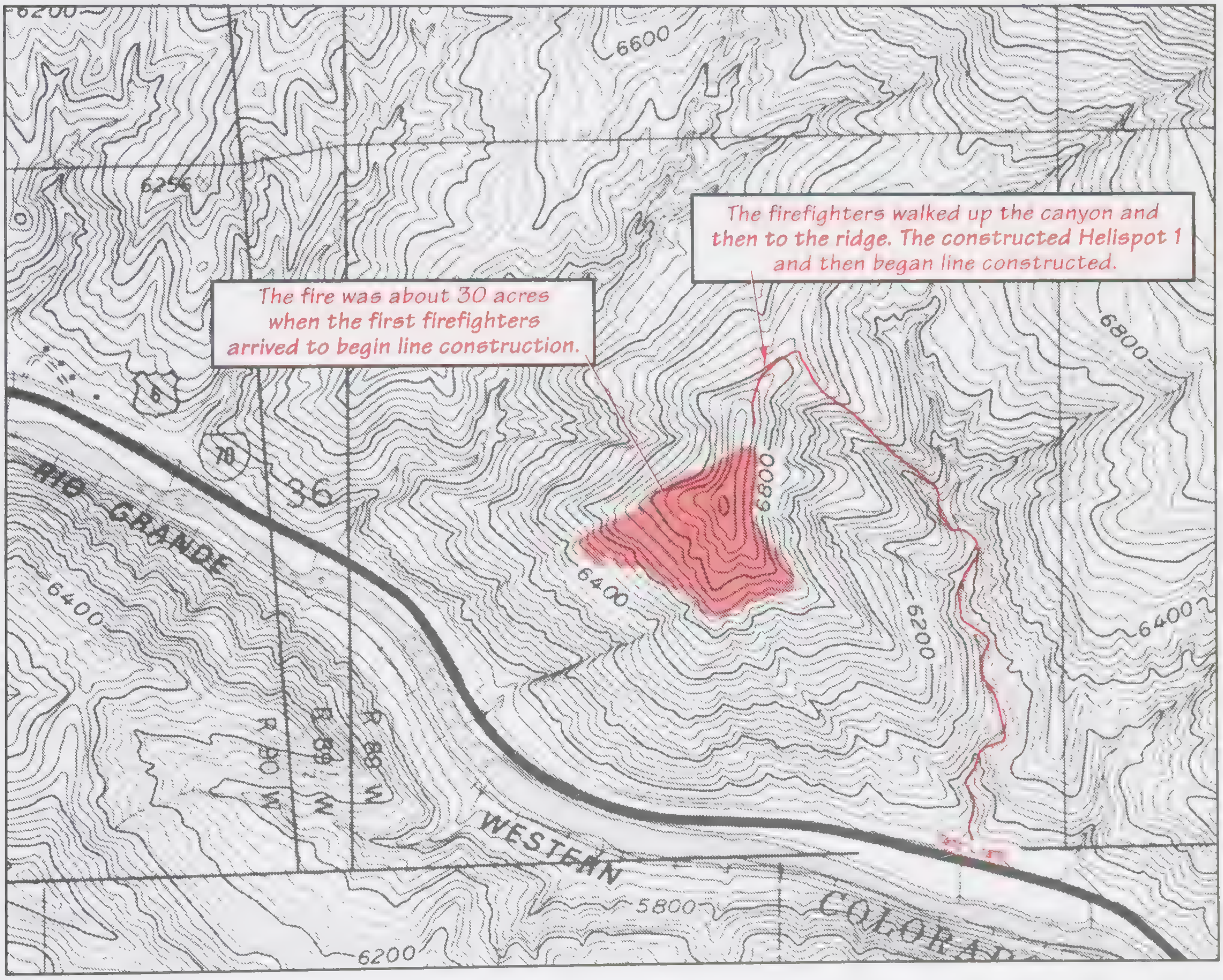
It was not a normal fire season.

July 3 - The fire was first reported to BLM authorities at 1100 hours. It was located about ½-mile north of Interstate 70, eight miles west of Glenwood Springs (Figure 5.34). The fire was on the top of the ridge, burning in pinon/juniper fuels, with no threat to structures. There were many other fires in the district and this one was not given a high priority. BLM forces were limited and only committed to a fire when lives or property were threatened, or the fire was active and running.

***WEATHER**: A red flag warning was issued for dry lightning and strong winds.*

July 4 - There were still 31 active fires within the district, and initial attack resources were not available. At noon the fire was three acres. The first firefighting resources (one BLM engine and one Forest Service engine) were dispatched late in the afternoon. By the time they arrived, it was too late for them to walk into the fire. It was felt that the terrain was too steep and treacherous for a night-time attack. The forces returned to their stations. By 2200 hours the fire had grown to about 11 acres.

Lightning started a fire just north of Interstate 70.



The firefighters walked up the canyon and then to the ridge. The constructed Helispot 1 and then began line constructed.

The fire was about 30 acres when the first firefighters arrived to begin line construction.

Figure 5.34 The South Canyon Fire was located just north of Interstate 70, west of Glenwood Springs. On July 5th, the first firefighters to actually attack the fire, parked their engines just off the highway and hiked into the fire. When they arrived the fire was about 30 acres. They constructed Helispot 1, then began constructing fireline.

WEATHER: A red flag warning was issued for dry lightning.

This fire was not high on the priority list.

July 5 - In the morning, the Incident Commander (IC) and 6 firefighters from two engines (one BLM and one Forest Service) hiked to the top of the ridge and constructed Helispot 1 (Figure 5.35). The IC ordered an additional engine, a helicopter, and one 20-person crew. They then started construction of line from the ridge down to the west.

Red flag warnings were issued for dry lightning.

Two loads of retardant were dropped by a heavy airtanker (Type 1) to support line construction. But the wind, steep terrain, and concern over rocks rolling onto Interstate 70 stopped any additional drops.

The IC and 6 firefighters hiked in to the fire and constructed a helispot.

At 1730 hours, the personnel on the fire left the fireline to return to their stations to repair equipment, and resupply. A squad of 8 smokejumpers had been substituted for the 20-person crew that the IC had ordered. This squad dropped on the ridge just north of the fire, at about 1745 hours. The IC instructed the Jumper-in-Charge (JIC) to continue working on the west flank. The JIC told the IC that the fire had crossed their line and was burning actively. The JIC ordered his crew to start line construction on the east flank. At midnight, the JIC ordered two Type 1 crews. The fire was now over 50 acres in size.

An airtanker dropped retardant.

Eight smokejumpers were dropped on the fire.

WEATHER: The morning fire weather forecast issued a red flag warning for very high to extreme fire danger. At 1920 hours the National Weather Service issued a red flag warning for Wednesday, July 6, because a cold front was to move through the area. It was predicted to pass through the Grand Junction District at about 1500 hours with winds shifting to the northwest at 15 to 25 miles per hour, with gusts to 30 to 35 mph.

Another red flag warning was issued, this one for extreme fire behavior.

July 6 - The squad of smokejumpers had stopped line construction at a little after midnight, because of darkness and the hazard of rolling rocks. At 0430 hours, the IC discussed the weather forecast with his dispatch office, then drove back to the fire. It took him and ten firefighters 3½ hours to hike into the fire, following the drainage just east of the fire. They constructed Helispot 2 and worked with the squad of smokejumpers on the fireline (Figure 5.35). At 0530 hours, the JIC ordered a helicopter for gear removal, and an aerial observation plane. The helicopter was substituted for the aerial observation plane. At 0845 hours, the IC and JIC discussed the strategy and tactics (Figure 5.36). They would continue to use a direct attack, cutting fireline along the ridge on the east side of the fire, and west down under the fire from the ridge below Helispot 1. At 0900 hours, the IC and several firefighters tuned their hand-held radios to the weather channel to get the general weather forecast.

The fire was active all night.

The IC and the JIC agreed to continue their direct attack.

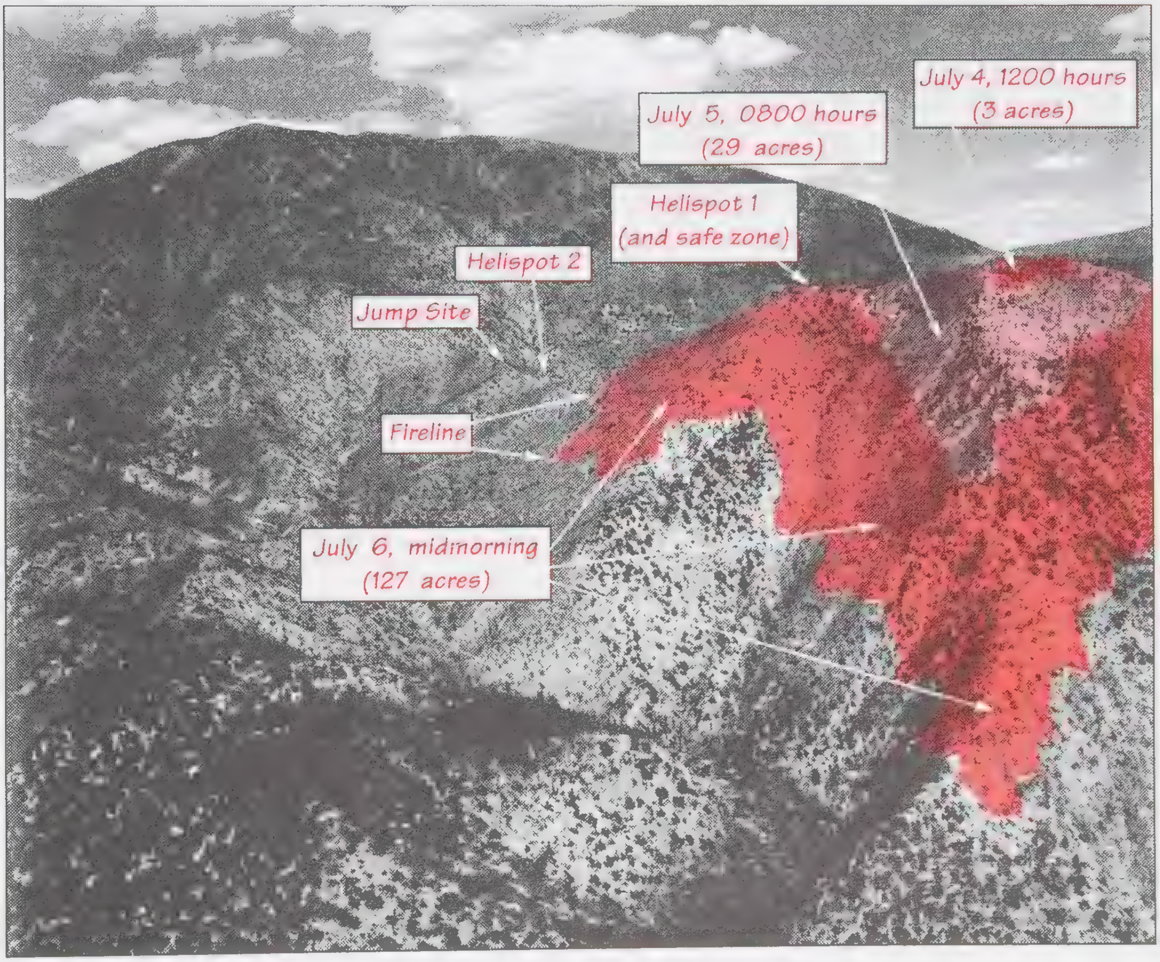

July 4, 1200 hours
(3 acres)
July 5, 0800 hours
(29 acres)
Helispot 1
(and safe zone)
Helispot 2
Jump Site
Fireline
July 6, midmorning
(127 acres)

Figure 5.35 The fire was about 127 acres on the morning of July 6.

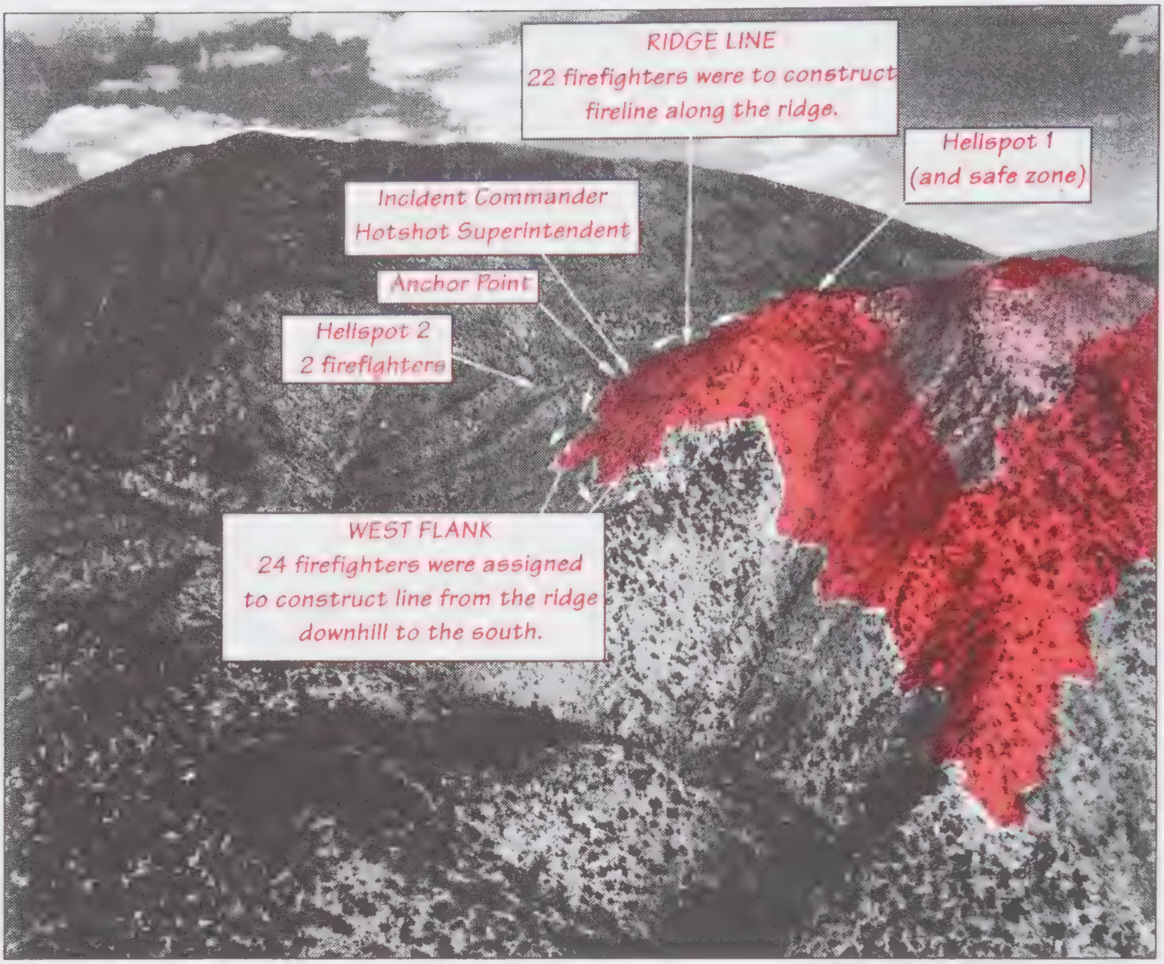

RIDGE LINE
22 firefighters were to construct fireline along the ridge.
Helispot 1 (and safe zone)
Incident Commander Hotshot Superintendent
Anchor Point
Helispot 2 2 firefighters
WEST FLANK
24 firefighters were assigned to construct line from the ridge downhill to the south.

Figure 5.36 A direct attack was planned. A group of firefighters were to work the east flank from the anchor point toward Helispot 1. An additional force was to drop off the ridge and construct undercut fireline on the west flank.

The red flag warning was still in effect.

***WEATHER**: The red flag warning issued at 1920 hours, July 5, was still in effect. It called for strong winds associated with the passage of a cold front. It should be noted that all of the previous red flag warnings had been for dry lightning and low relative humidities.*

There was some discussion over the lack of safety zones.

0930 hours - The helicopter arrived. It was to be held for initial attack, so it was restricted to four hours of flight time. The IC and JIC took a reconnaissance flight and agreed to continue their direct attack. The JIC and another jumper discussed the lack of safety zones, but continued to construct fireline.

1030 hours - Eight more smokejumpers dropped into the jump area. They were assigned to assist on the west flank. At 1100 hours, the Prineville Hotshot Crew arrived at the heliport.

By 1230 hours, the hotshot superintendent and nine firefighters were flown into Helispot 2. The IC, JIC, and hotshot superintendent discussed the overall plan. It was decided to have the nine hotshots assist on the construction of line on the west flank.

1300 hours - There was a flare-up on the west flank, forcing a retreat. The helicopter dropped water on the flare-up, cooling it. After the water drop, the crews continued to construct fireline.

A flare-up forced a retreat.

> ***WEATHER**: Between 1200 and 1300 hours, the winds 80 miles to the west of Grand Junction increased from 10 miles per hour to 22 miles per hour, with gusts to 30 mph.*

The winds in the region were picking up, as predicted.

1400 hours - The firefighters working the west flank stopped for a lunch break on the first major spur ridge along the west flank. During lunch, several of the firefighters discussed the fire orders and "watch outs!" that they were compromising. At 1430 hours, three smokejumpers and nine hotshots were instructed to work back up the west flank to watch for spot fires and improve the fireline. The line scout continued to mark line from the lunch spot. The remaining group of firefighters sharpened their chain saws in preparation for continuing their assignment.

Despite some concern over the safety of what they were doing, they continued.

1500 hours - The last ten members of the Prineville Hotshot crew were flown into Helispot 2. They were assigned to check for spot fires and widen the line on the east flank of the fire.

> ***WEATHER**: At 1520 hours, a dry-cold front with strong winds moved into the fire area.*

1545 hours - Fire activity was picking up. The fire made several rapid runs within the burn, with 100-foot flame lengths. Helicopter drops were requested for the west flank and on the ridge, but the fire behavior was too intense; the drops were ineffective. Firefighters along the west line began to move out (Figure 5.37).

The weather was changing and causing an increase in fire behavior.

1600 hours - The fire crossed the narrow canyon below the west flank fireline. This spot quickly developed as it was pushed by an up-canyon wind. At this point, all firefighters on the west

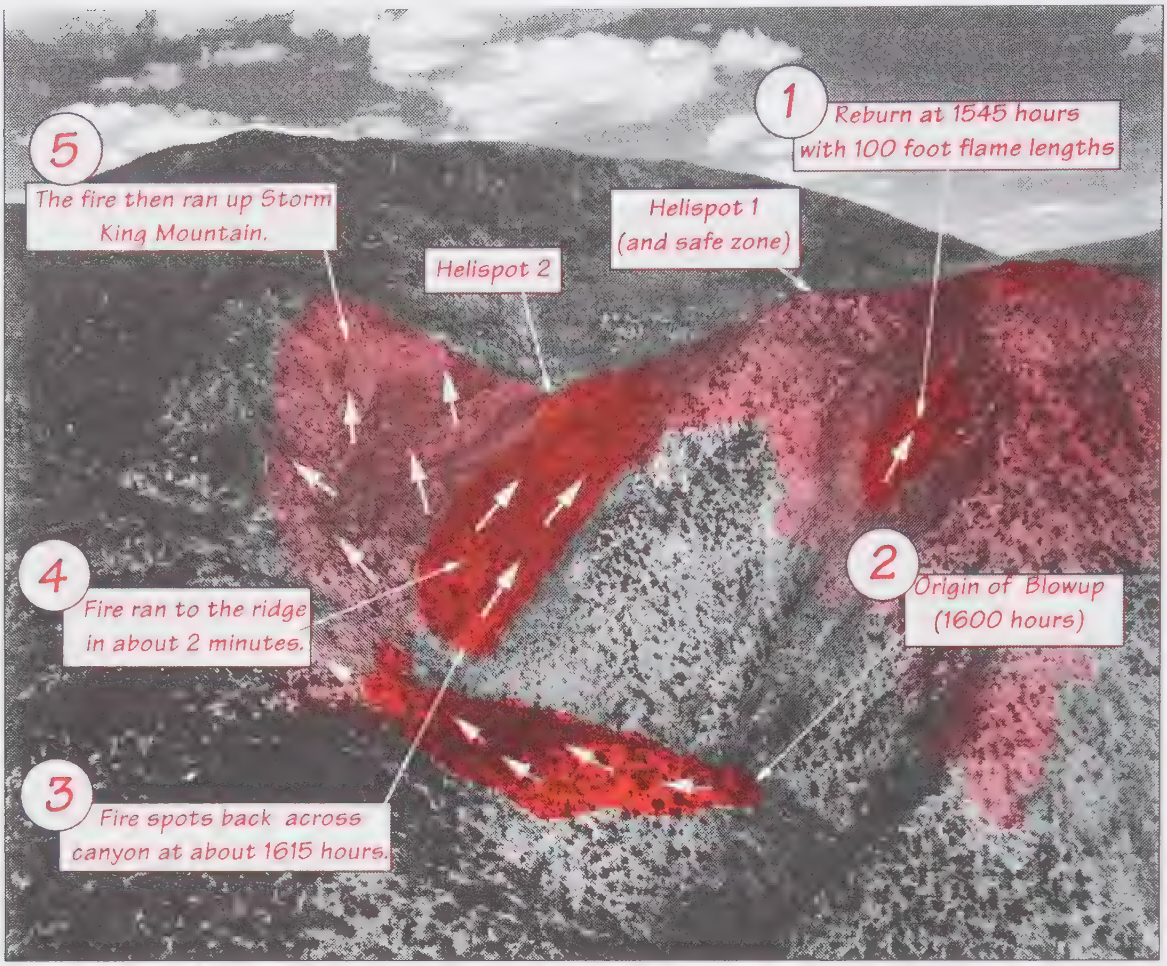
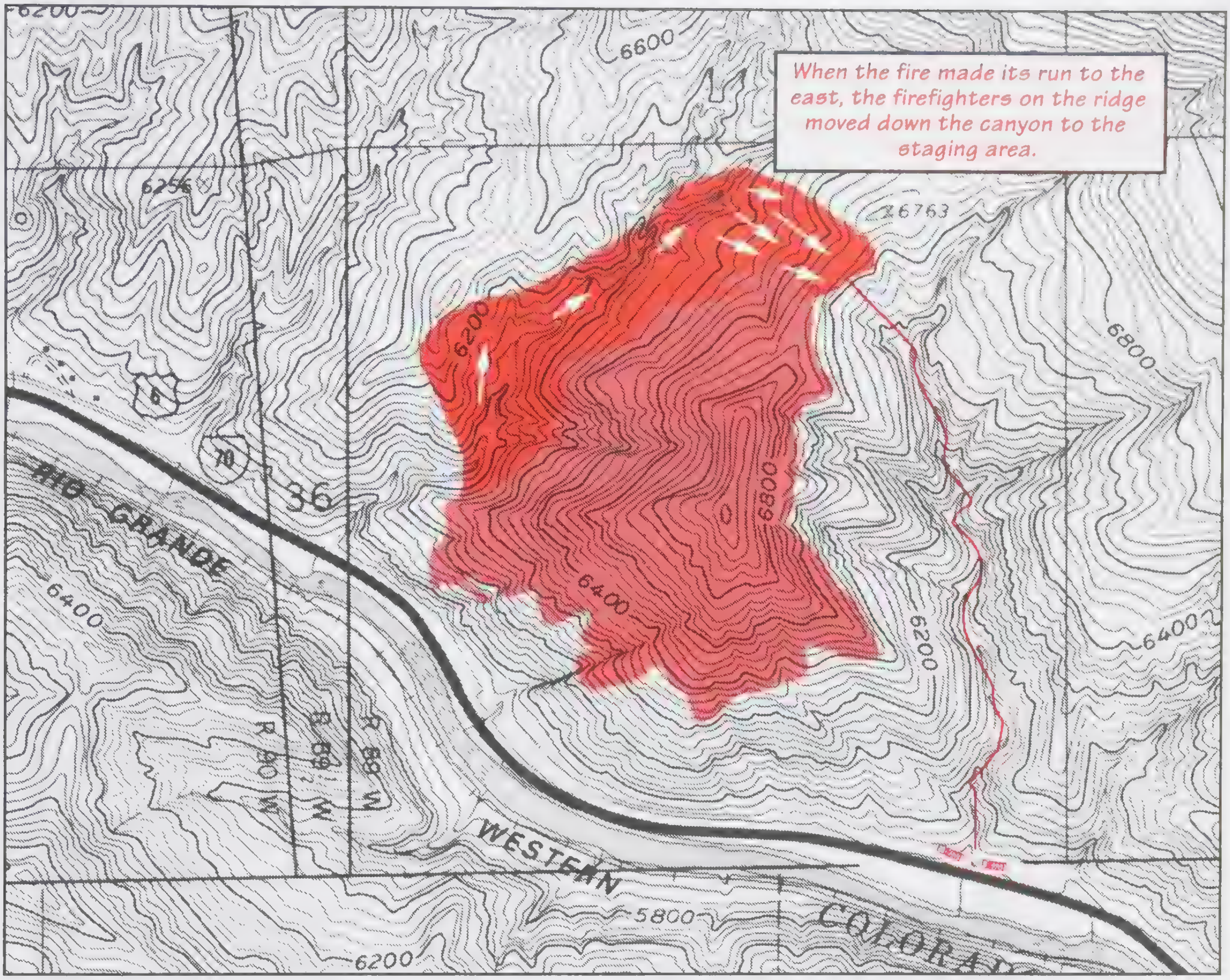

1
Reburn at 1545 hours with 100 foot flame lengths
5
The fire then ran up Storm King Mountain.
Helispot 1 (and safe zone)
Helispot 2
4
Fire ran to the ridge in about 2 minutes.
2
Origin of Blowup (1600 hours)
3
Fire spots back across canyon at about 1615 hours.

Figure 5.37 A reburn, with 100-foot flame lengths, occurred at about 1545 hours (Point 1). At 1600 hours, the fire crossed the narrow canyon across from the west flank fireline and began burning in a north-northeastly direction, pushed by a strong up-canyon wind (Point 2). In about 15 minutes, the fire spotted back across the canyon on the slope below the west flank fireline and the retreating firefighters (Point 3). Once the fire reached the west facing slope, now being pushed by a 40 mile per hour upslope wind, it quickly moved to the ridge line, overrunning 12 firefighters. It is estimated that this ¼-mile run took less than two minutes (Point 4). The fire then ran up and over Storm King Mountain, killing two more firefighters (Point 5).

flank were ordered to withdraw. The firefighters on the ridge were told to move to the safety zone at Helispot 1. The fire was "rolling" up the slope, across and below the west flank.

The firefighters on the ridge were prevented from reaching the safety zone.

The firefighters on the ridge were prevented from reaching the safety zone, because they were cut off by fire. They were told to retreat toward Helispot 2, and were then ordered to escape down the east slope and drainage, back to Interstate 70. This group escaped with only minor injuries. The escape route was



When the fire made its run to the east, the firefighters on the ridge moved down the canyon to the staging area.

Figure 5.38 The firefighters working the east flank were cut off from reaching the safety zone at Helispot 1. They then were ordered to drop off the ridge to the east, escaping down the canyon to Interstate 70.

overrun by fire about 40 minutes after they reached the Interstate (Figure 5.38).

The two firefighters at Helispot 2 elected to try to outflank the fire.

The two firefighters assigned to Helispot 2 did not elect to follow the group down the east drainage, but attempted to outrun the fire by moving to the west. Their escape was cut off by a steep chute, and they were caught as the fire moved up and over Storm King Mountain.

Several firefighters moved up the steep slope toward the ridge; they deployed shelters.

1612 hours (approximately) - The fire had moved up the opposite ridge to a point where it was below the retreating firefighters. The IC radioed his dispatcher and told them he was

The winds were now 40 mph.

Within two minutes the fire crested the ridge; 12 firefighters were caught along the fireline.

losing the fire and needed air support. The eight firefighters still at the lunch spot moved up the spur ridge toward the main ridge and Helispot 1. They deployed shelters near the top of the ridge and survived. The line scout stayed near the lunch spot, did not deploy his shelter, and also survived.

> ***WEATHER****: The wind was now so strong, the smokejumpers moving up the ridge had to use their chin straps to keep their headgear in place.*

1614 to 1618 hours - The fire spotted back across the narrow canyon onto the slope below the west flank fireline. The fire

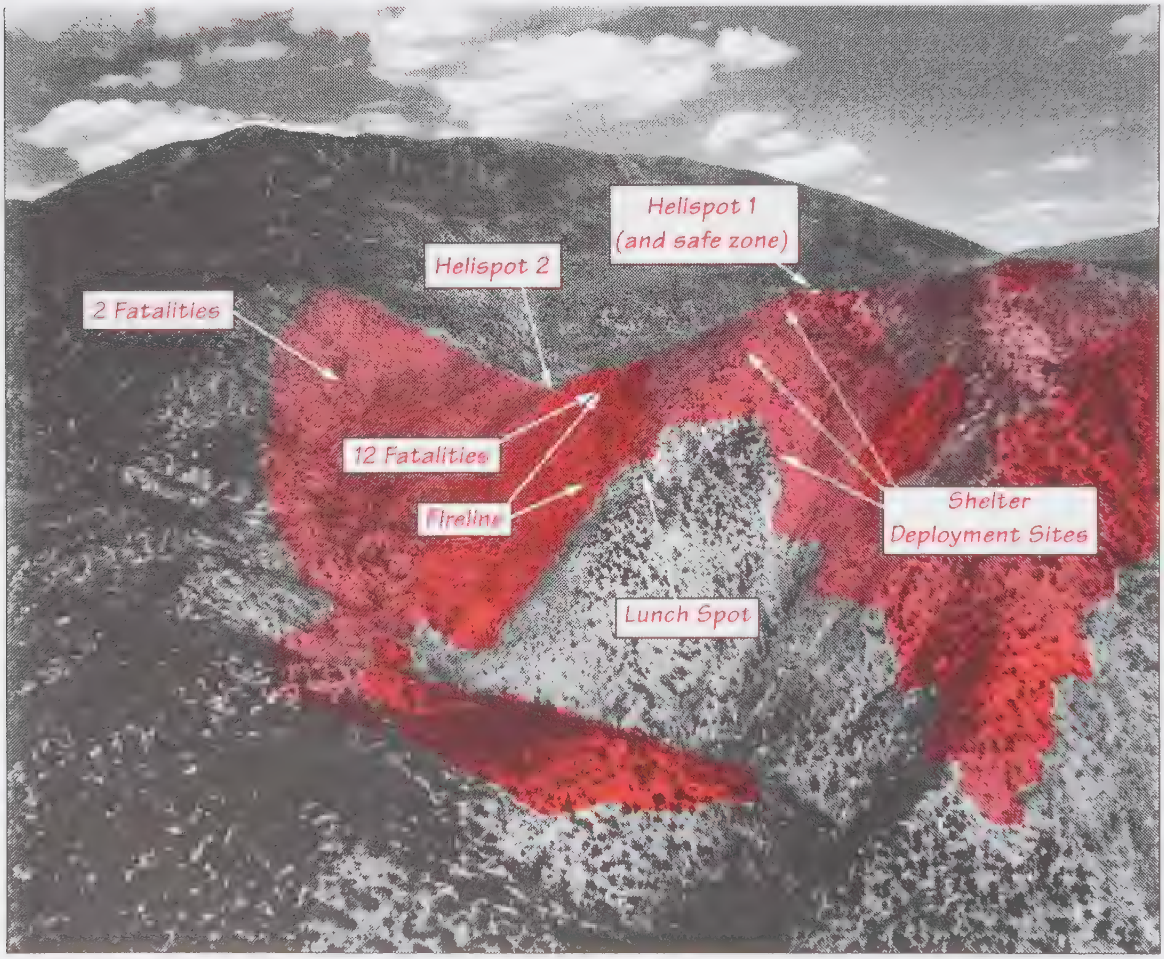


Figure 5.39 12 firefighters were overrun, and died just under the ridge line on the west flank fireline. The two firefighters assigned to helitack operations tried to outrun the fire by moving north and west. Their escape was stopped by a steep chute; they were also overrun and killed.

then began its run to the ridge, being pushed by a 40 mile per hour upslope wind. The fire overtook the retreating firefighters and hit the ridge in 2 minutes. By 1624 hours, the whole area was on fire, and 14 of the 49 firefighters on the fireline were dead (Figure 5.39).

The wind event was predicted.

Critique

There were many warning signs that this fire was not going to be an easy one to control. Some of the more obvious ones were:

There were indications the fire behavior was picking up.

- **Weather** - The forecast was for strong, gusting winds from the northwest. Most people on the fire knew this, but apparently did not relate it to what might happen.
- **Fire behavior** - Throughout the life of the fire, the fire behavior had been greater than what would be expected for a routine initial attack fire. The fire actually grew more at night than during the day. Starting at about 1300 hours, the weather factors began to change. The flammability of the west and south slopes was apparently not considered.

There were not enough firefighting resources to do what they had planned.

- **Terrain** - The steepness and aspect of the slopes were a problem. The steepness of the slope complicated line construction and hampered all of the firefighters as they tried to escape. The aspect played a role in the flammability of the fuels.
- **Firefighting resources** - The fire was not getting all of the resources needed and requested. Eight-person squads of smokejumpers were being substituted for the 20-person crews that were requested. A single helicopter was provided to move equipment, make water drops, and provide aerial surveillance, as well as be ready for initial attack assignments in the area. This was too many assignments for one helicopter.

The fire had dried out the fuels, making them "ripe" for a reburn.

- **Fuels** - Much of the fuel along the west flank consisted of gambel oak, and some of the fuel had the understory burned out from under it.
- **Fire season** - This was not a normal fire season. The area was having more fires than normal, and these fires were getting much larger.
- **Escape routes and safety zones** - Basically there were none. Helispot 1 had been designated a safety zone, but it was uphill and couldn't be reached in a reasonable time.

There were no safety zones.

- **Strategy and tactics not adjusted** - Even as conditions were changing, the strategy of constructing miles of undercut line on mid-slope with inadequate firefighting resources was not evaluated and changed.

Did they go on a "trip to Abilene"?

- **Complacency of personnel** - Some of the firefighters assigned to the fireline discussed various safety issues, but did nothing about them. They just continued to fight fire like everything was okay.

What would you do?

What would you have done differently? Now that we know what happened, we can say we'd have come off the hill hours before the fire exploded, killing 14 firefighters. But, from a fire officer's point of view, what could you have done differently?

How would you track the weather?

As the fire officer in this situation, here are some questions you probably should ask yourself:

- Based on the fire season to date, what can I expect the fire behavior to be on this fire?
- Based on the weather of the last three days, what can I expect the fire behavior to be?
- Based on the predicted weather, what can I expect to happen?
- If I'm not getting the firefighting resources that have been requested, how should I modify the strategy and tactics?
- I cannot see all of the fire. Where should I place lookouts, and how will I communicate with them?
- We need to establish safety zones and escape routes. Where and how will we do this? If we can't, how will we adjust the strategy and tactics?
- What are the safety concerns on this fire?
- Is the Interstate a real or perceived problem?

What would be your plan?

In developing your plan, here is some food for thought:

- **Objectives and plan** - The first step should be a plan based on some simple objectives. If the objectives for the fire had been laid out, they would have "flagged" the times to change the plan. The objectives may have read like this:
  - Keep the fire from moving to the east, from the ridge.
  - Keep the fire from moving so close to the Interstate that it causes rolling material to interfere with traffic.
  - *Keep the fire under 50 acres.*

If these simple objectives were laid out, it would have been obvious that the second and third objectives were not going to be met. Look at how close the fire was getting to the highway. They just did not have adequate firefighting resources to keep the fire on the hill. On the morning of July 6, the fire was already over 100 acres.

- **Safety zones and escape routes** - If you are at the top of the ridge and are considering constructing fireline downhill, develop a realistic plan of how you will escape and where you will seek shelter. Constructing line downhill is an inherently dangerous strategy! If you decide you can't develop an escape plan, change your strategy. Don't be complacent and say "I've done this before and nothing happened."
- **Weather forecasts** - You cannot ignore the weather forecast. There is no sign that personnel on the South Canyon Fire took the predicted weather into account, when developing or revising their plan, strategy, or tactics.
- **Appreciation for potential fire behavior** - This was not a normal fire season. This was not a normal summer day. This was not a normal fire. Then why use a normal attack strategy? Look up, look down, and surely look around. These are potentially dangerous situations. You must recognize what may happen if fire gets below the fireline and plan for this possibility. The warning signs were there and observed; apparently they were not communicated or understood.

How would you establish safety zones?

Tunnel Fire

City of Oakland
Oakland Fire Department
California

25 people died in an urban/wildland fire.

The Tunnel Fire occurred in October of 1991, in the cities of Oakland, Berkeley, and Piedmont in California. It was one of the most destructive natural disasters in recent history. When the fire exploded into a conflagration on October 20, it took the lives of 23 civilians, 1 fire department battalion chief, and 1 police officer; and destroyed over 3,800 homes, condominiums, or apartments.

Background

The Oakland and Berkeley hills have seen major structure-loss fires before. In 1923, 584 homes were lost in one of the first urban/wildland fires in California. More than 36 homes were lost in the Fish Fire on September 22, 1970.

The San Francisco Bay Area is normally "bathed" by an onshore flow of cool, damp air, because of its proximity to the Pacific Ocean. But, the area sometimes experiences a particular weather pattern that can cause real havoc. This pattern occurs when a high-pressure system positions itself in the Great Basin east of the Sierra Nevada Mountains, and a low-pressure system is positioned off the central California coast. As the wind flows out of the northeast, across the mountains and hills of the coastal range, it heats and dries out.

The area was normally cool and damp.

Most of California was extremely dry due to a five-year drought; the Oakland and Berkeley hills were no exception. The area had also suffered from an extreme freeze the year before, killing or damaging all of the less cold-tolerant vegetation. The week before the fire, temperatures had been unseasonably hot and dry.

They were in a drought condition.

The area in which the fire burned is accessed by very narrow, winding roads; parking space is at a premium. The homes, condominiums, and apartment buildings are closely spaced, and natural vegetation or landscaping is abundant. The water system is old and limited in water supply capacity.

October 19

There were no signs of unusual winds in the area. The winds were blowing at higher elevations and farther north in the state.

> ***WEATHER**: At 0930 hours, October 19, 1991, the fire weather forecast for the Oakland area included a red flag warning for "stronger northerly winds and lowering humidities."*

Red flag warnings were issued for strong winds and low relative humidities.

1212 hours - A fire was reported at 7151 Buckingham Blvd. in the City of Oakland. The fire department dispatched three engines and two battalion chiefs. The winds were onshore at about 5 miles per hour. In the next 12 minutes, the fire went to a 4th alarm with a total commitment of 10 engines, 2 trucks, and 3 battalion chiefs. The fire was running north from Buckingham

Blvd. up the hill toward Grizzly Peak Boulevard. The attack was from the origin, up both flanks toward the head.

1225 hours - Battalion 2 established his incident command post and was designated "Tunnel Command."

1237 hours - East Bay Regional Parks was notified of the fire and asked to send a full wildland response. They responded with 2 engines, 2 water tenders, and 4 patrol units.

A heavy dispatch was made to a grass fire.

The fire was quickly contained.

1240 hours - The California Department of Forestry (CDF) was notified. Their initial response was 2 engines, 1 helitack unit, and a battalion chief. Within minutes, 4 additional CDF engines were dispatched. The area is in a mutual threat zone, thus the automatic notification of CDF forces.

1300 hours - The mutual aid system was activated. Surrounding fire agencies were put on alert for possible dispatch, or were requested to the scene, or to cover open fire stations.

1400 hours - The fire was contained at five acres (Figure 5.40). All of the equipment was released from the fire by 1900 hours. Engine 19 did return after dinner to check the fire.

***WEATHER**: The afternoon forecast, issued at 1530 hours, continued to call for a red flag warning for strong northeastly winds and low relative humidities.*

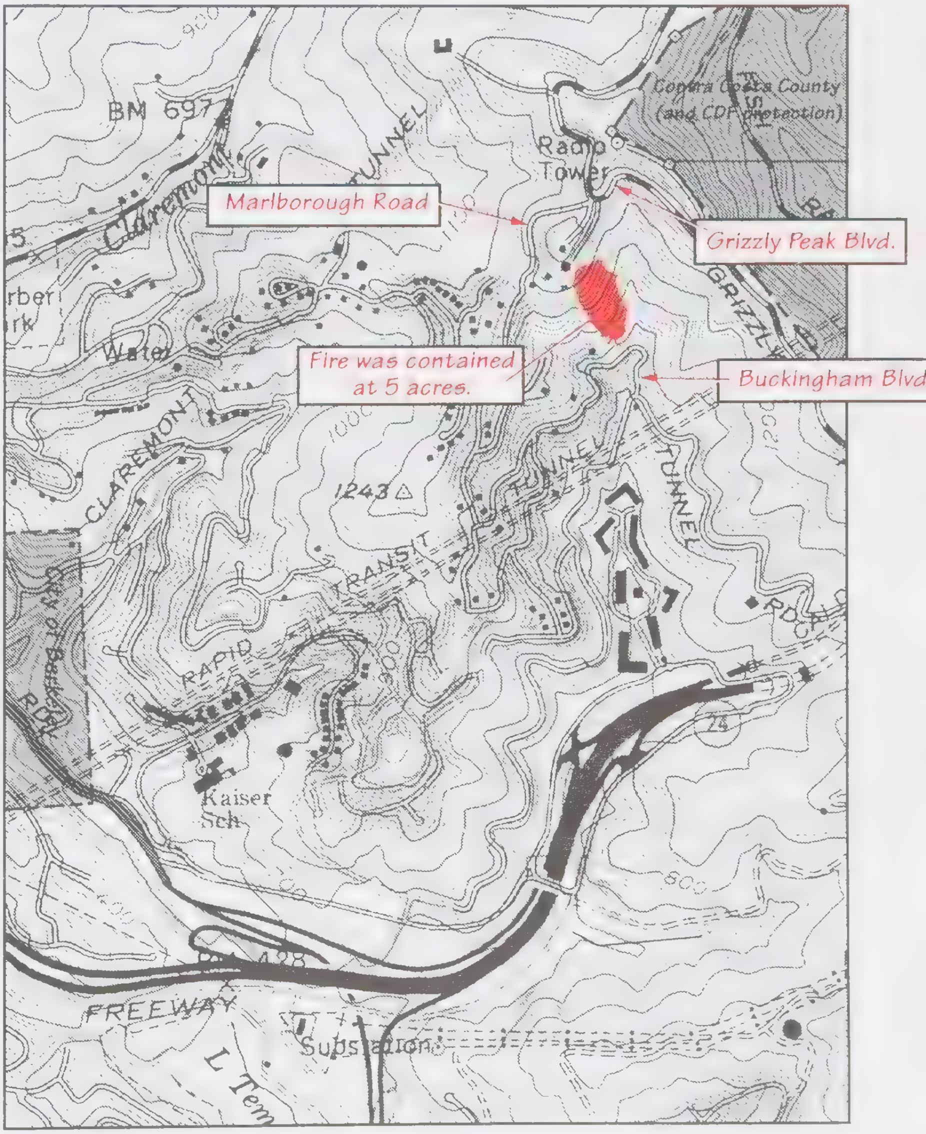

Contra Costa County (and CDF protection)
BM 697
Radio Tower
Marlborough Road
Grizzly Peak Blvd.
Fire was contained at 5 acres.
Buckingham Blvd
Claremont
TUNNEL
CLAREMONT
1243
RAPID TRANSIT TUNNEL
Kaiser Sch
City of Berkeley
FREEWAY
Substation

Figure 5.40 The fire on October 19 was contained at about 5 acres.

October 20

The morning shift change had been completed. Engines 19 and 24 were assigned to the fire to check for flare-ups and to remove the hose lines that were left in place the previous day. The winds were blowing, so staffing was increased and special patrols were activated.

The red flag warnings were still in effect.

0853 hours - Engine 19 personnel spotted what they thought was smoke and started mop-up operations. Engine 24 noted the winds were from the east, light and variable. They also noticed several hot spots in the duff under the pine trees.

0908 hours - Engine 24 reported that the winds were now 25 miles per hour. Engine 16 and East Bay Regional Parks were requested to assist in the removal of fire hose.

After shift change, forces returned to the fire to retrieve the hose lines.

0929 hours - Battalion 2 reestablished "Tunnel Command."

0935 hours - Engine 27, located several miles south of the fire, reported "the winds are over 55 miles per hour at Skyline and Keller."

1000 hours - Battalion 2 left the fire, assigning Engine 19 as Tunnel Command.

1004 hours - Four East Bay Regional Parks units were positioned above the fire at the water tanks. The wind was blowing hard enough to blow chunks of insulation from nearby buildings.

1030 hours - Engine 16 told Tunnel Command he could see fire. "We've got fire burning down at the bottom of the burn!" Forces moved into the area and began working on the hot spots.

The wind was beginning to surface.

1052 hours - East Bay Regional Parks Engine 5669 asked his dispatcher to have the city request a helicopter, because they were having all kinds of flare-ups.

1058 hours - Tunnel Command asked for a 1st alarm assignment. "We have flames, visible flames showing on the lower east flank." Within minutes, the fire crossed Buckingham Blvd. moving to the southwest. Structures were immediately involved. Four minutes into the event, the fire crossed Marlborough Road, engulfing structures in its path. In the next several minutes, the fire was moved to a 3rd alarm, and assistance from CDF and other agencies was put in motion.

Fire was seen on the east flank of the fire.

1115 hours - Battalion 2 arrived above the fire on Grizzly Peak Road, reassumed command and ordered a 4th alarm. Two minutes later, Engine 4 reported that there were two fronts to the fire. The fire was moving uphill toward Grizzly Peak Road, and down-canyon across Buckingham Blvd.

Within minutes the fire went to four alarms.

1130 hours - Tunnel Command had now ordered a 6th alarm, air support, and 10 mutual aid engine strike teams. By this time, the fire had crossed Grizzly Peak Road. Engine 6 already reported they were having problems with the water supply.

Within thirty minutes the fire was at six alarms.

1133 hours - "Tunnel Operations" reported that the fire was 100 acres; structures were being lost. By this time, the fire had moved about a mile to the southwest, crossing Tunnel Road and Highway 24 (Figure 5.41).

1155 hours - The fire was at the Parkwood Apartments.

1300 hours - By this time, the Berkeley Fire Department had established its own command structure at its end of the fire, and had dispatched every engine company in the city to the fire.

Within the first hour 700 structures were lost.

1305 hours - Joint police/fire command was discussed. It was decided to have separate command posts, but there was a ranking police department official assigned to the fire department command team.

1400 to 1630 hours - The fire was being pushed by strong north to east winds. It again jumped Highway 24 in its move south. Battalion Chief 4 and a police officer were killed during rescue and evacuation operations; 23 civilians were also killed that afternoon.

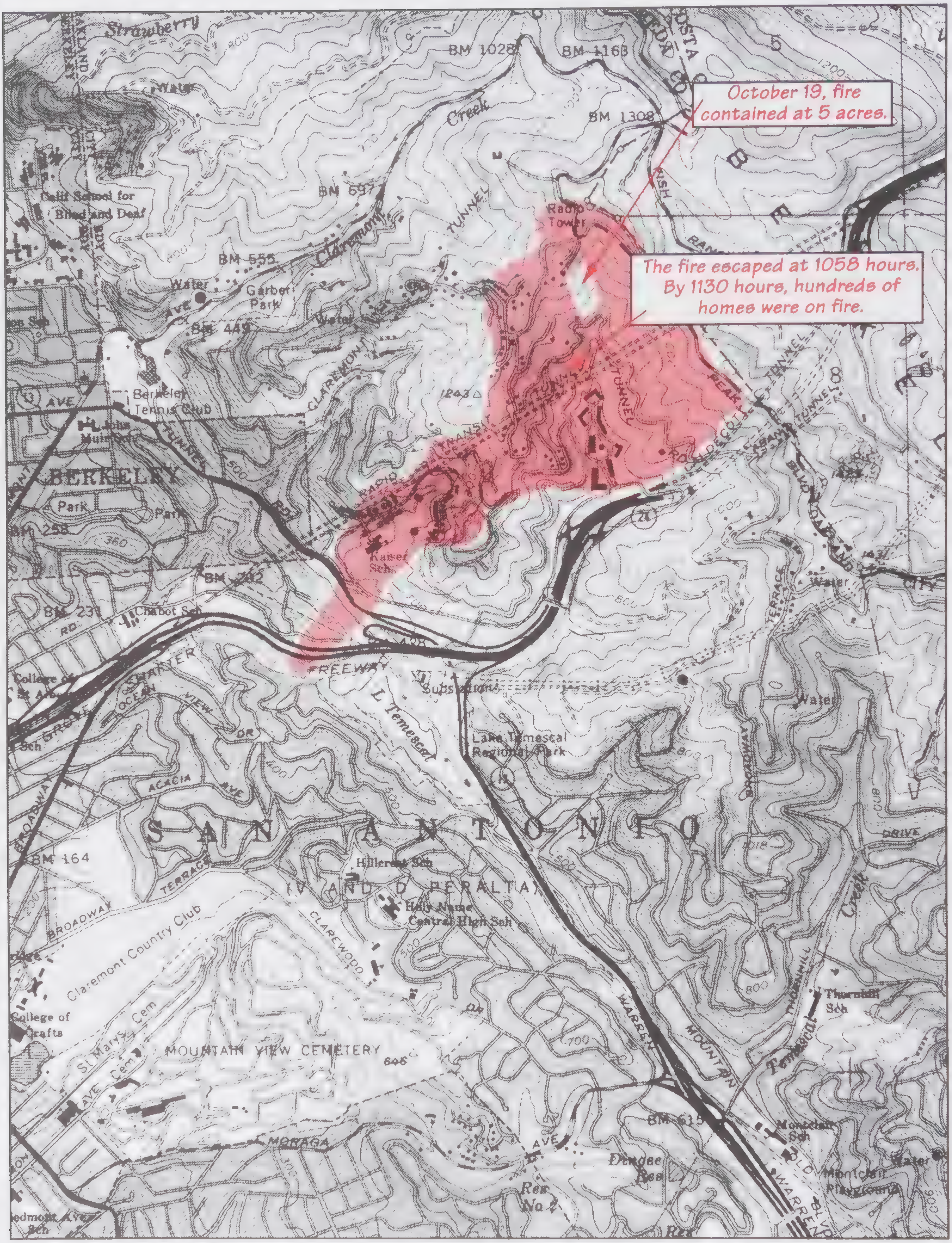
One of the city battalion chiefs was killed by a falling power pole. A police officer was killed in the fire storm.

1545 hours - A major incident command team was requested through the California Office of Emergency Services. The order was filled with one of CDF's teams.

1800 hours - Air operations were stopped because of darkness. The wind was dying down and shifting directions. Spotting was still a problem.

2100 hours - The fire began to lay down; the worst was over (Figure 5.42).

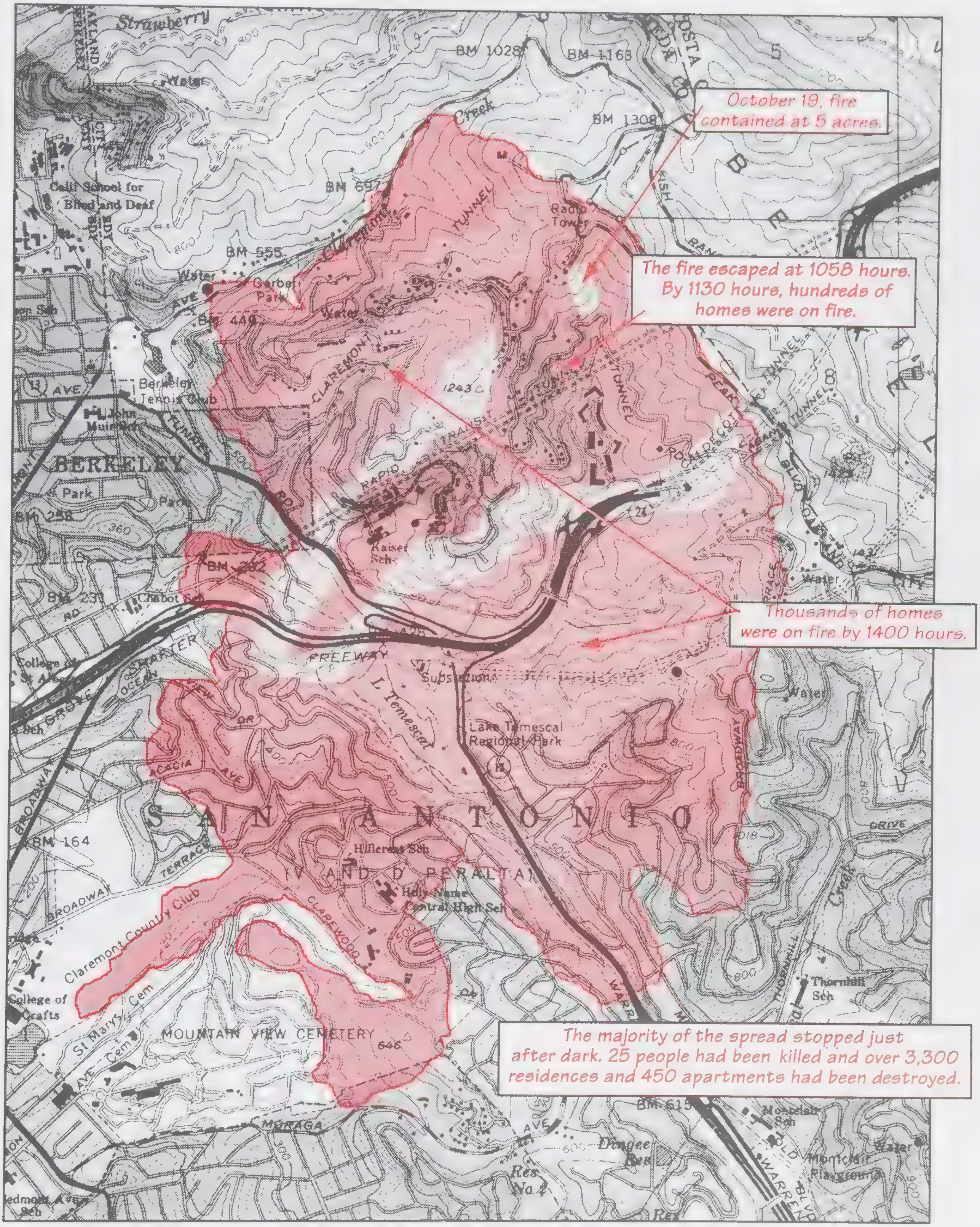
The fire was officially contained at noon on October 22, and declared under control the next morning. The fire killed 25 people and injured 150 more. It burned 1,600 acres; destroyed


October 19, fire contained at 5 acres.

The fire escaped at 1058 hours. By 1130 hours, hundreds of homes were on fire.

Strawberry
BM 1028
BM 1163
BM 1308
Creek
Claremont
BM 697
Calif School for Blind and Deaf
Radio Tower
TUNNEL
BM 555
Water
Garber Park
BM 449
Berkeley Tennis Club
BERKELEY
Park
BM 258
BM 232
BM 239
Chabot Sch
Kaiser Sch
FREEWAY
Substation
L Temescal
Lake Temescal Regional Park
SAN ANTONIO
Hillcrest Sch
(V AND D PERALTA)
Holy Names Central High Sch
BM 164
BROADWAY
Claremont Country Club
CLAREWOOD
College of Crafts
MOUNTAIN VIEW CEMETERY
St Marys Cem
MORAGA
AVE
Dingee Res
Res No 2
BM 615
Montclair Sch
Montclair Playground
WARREN
MOUNTAIN
Thornhill Sch
Temescal Creek
Water

Figure 5.41 The fire was now running hard to the southwest. Hundreds of homes burned in the first hour of the "blowup."



October 19, fire contained at 5 acres.

The fire escaped at 1058 hours. By 1130 hours, hundreds of homes were on fire.

Thousands of homes were on fire by 1400 hours.

The majority of the spread stopped just after dark. 25 people had been killed and over 3,300 residences and 450 apartments had been destroyed.

Strawberry
BM 1028
BM 1163
BM 1308
Creek
BM 697
Calif School for Blind and Deaf
Radio Tower
BM 555
Water
Garber Park
BM 449
TUNNEL
CLAREMONT
1243
Berkeley Tennis Club
John Muir Sch
BERKELEY
Park
BM 258
CALDECOTT
BM 302
BM 231
Chabot Sch
College of St Albans
RAPID TRAIL
Kaiser Sch
FREEWAY
Substation
L Temescal
Lake Temescal Regional Park
24
13
SAN ANTONIO
V AND D PERALTA
Hillcrest Sch
Holy Names Central High Sch
ACACIA AVE
BROADWAY
BM 164
TERRACE
Claremont Country Club
CLAREWOOD
College of Arts and Crafts
St Marys Cem
MOUNTAIN VIEW CEMETERY
646
MORAGA AVE
BM 615
Dingee Res
Res No 2
Montclair Sch
Montclair Playground
WARREN BLVD
Thornhill Sch
Creek
Water
BROADWAY
DRIVE
Piedmont Ave Sch

Figure 5.42 The wind stopped and the spread slowed.

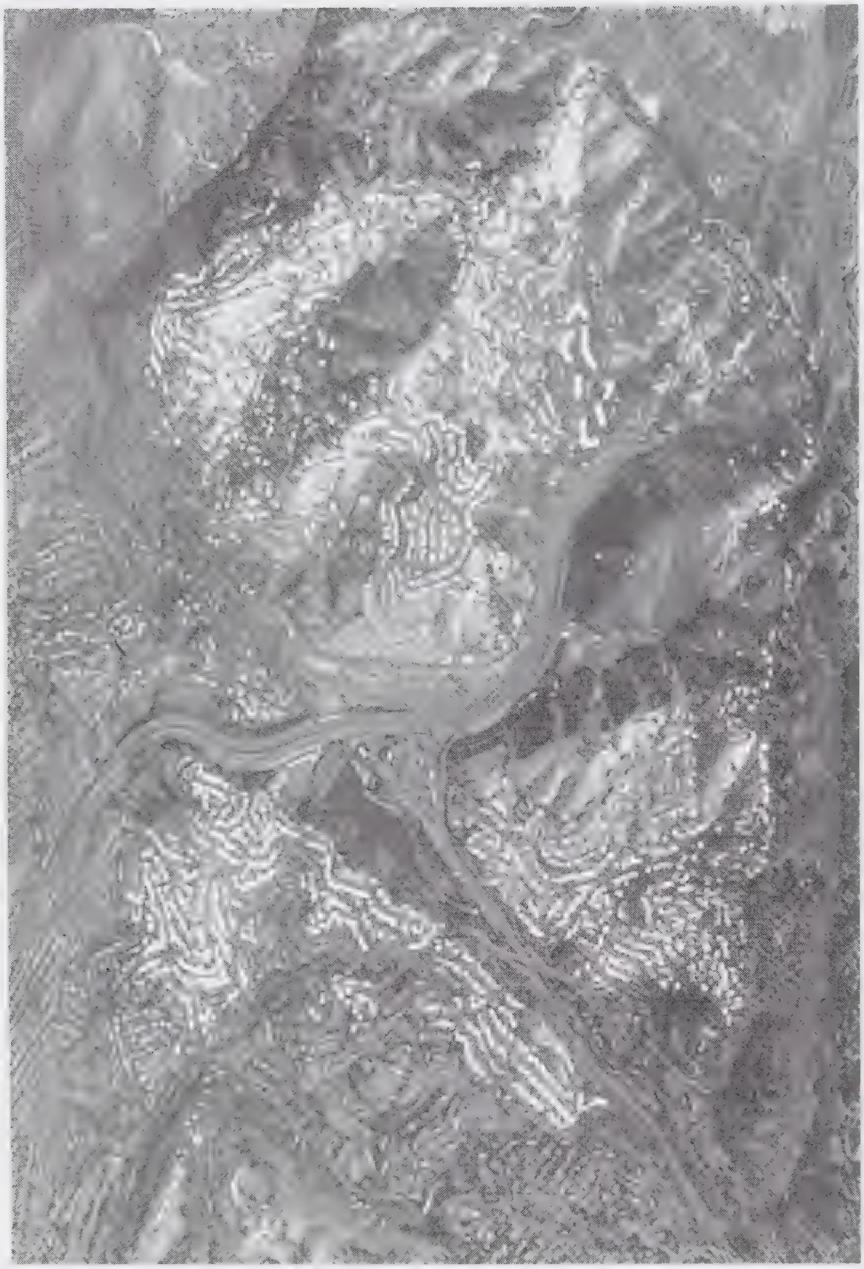


Figure 5.43 This photograph was taken by a NASA aircraft on the morning of October 21 using infrared film. Each of the white squares represents a burned out foundation.

3,354 single family residences and 456 apartments; and did an estimated $1.5 billion in damage (Figure 5.43).

At the peak of the firefight, the cities of Oakland, Berkeley, and Piedmont were fully committed. The mutual aid system provided 440 engines, 6 airtankers, 16 helicopters, and hundreds of law enforcement, command, logistical support, and search and rescue personnel.

Critique

What can be learned from a disaster like this? Once the fire began to move on the afternoon of October 20, there was nothing that could be done. The best that could be hoped for was "organized chaos." It was going to "do its thing" until the wind diminished. The main lessons to be learned are found in the events of the previous day, after the original fire was contained. What was or wasn't done that led to this disaster?

3,354 single family residences were lost.

The response to the original fire was swift, heavy, and effective. The fire was quickly contained at about five acres. Once the fire was knocked down, however, there was limited action to control it. The fire was in grass, brush, and heavy pine needle duff. It was contained on the side of a hill. They were not able to tie it to any roads or other breaks in the fuel. The majority of the fire was contained using wet line; there was limited handline constructed. There was limited mop-up or overhaul of the fire. All of the firefighting forces were back in quarters by nightfall. The hose lays were left in place to facilitate use if a flare-up occurred.

There was limited mop-up of the fire.

Shift change occurred on schedule. Two engines were assigned to the fire to primarily retrieve the hose. The weather was still abnormally warm and dry. There were red flag warnings posted for strong, dry winds, but no one was ensuring the last spark was snuffed out. There was no appreciation for how difficult it is to fully suppress a fire in heavy pine needle duff with only one or two squirts of water.

If there is one lesson to be learned from the Tunnel Fire, it is that you as a fire officer MUST ensure that the fire is out, totally out. The rules of mopping up a fire are:

- Start work on each portion of line as soon as possible.
- Secure and extinguish burning materials.
- Construct fireline to mineral soil.
- Deal with special hazards INSIDE the line.
- Deal with special hazards OUTSIDE the line.
- Reinforce the fireline.
- Check for spot fires.

There was no work done on the fire for close to 12 hours.

This fire technically can't be called a rekindle, because the fire department hadn't returned the area back to the landowner, but it is as close to one as you ever want to get. Rekindles are avoidable.

There were signs that this fire shouldn't be handled in a routine manner. The two main signals were that the weather was abnormally warm and dry, and that there was a red flag warning for strong, dry winds.

What would you do?

Based on this information, what would you do as a fire officer to help ensure the fire would not escape containment? The two primary resources needed to conduct a full and complete mop-up, personnel and water, were available. One plan of attack would have been to assign one or two companies to work from the top, down both sides, and to have two additional companies

Mop-up is critical.

work from the bottom up. This work could have been done safely until midnight; meals could have been provided for dinner. The next morning, at daylight, two or three companies could have returned to finish the mop-up and to remove the hose lays. The shift change for the engines could have been accomplished on the fire ground.

What would you have done?

There was a need for urgency: high winds were predicted, and there was a history of nasty fires in this area under similar conditions. This need for urgency dictated an all-out effort to ensure the fire could not escape.

Miller's Reach Fire #2

Big Lake District
Alaska Division of Forestry
Alaska

Background

The 1996 fire season in Alaska started early. The winter had been very cold and dry. Some areas of the state received only a quarter of their normal precipitation. As of late December, the total snowfall in Fairbanks was 11 inches; normal is close to 43 inches.

344 structures were lost in the worst urban/wildland fire in Alaska's history.

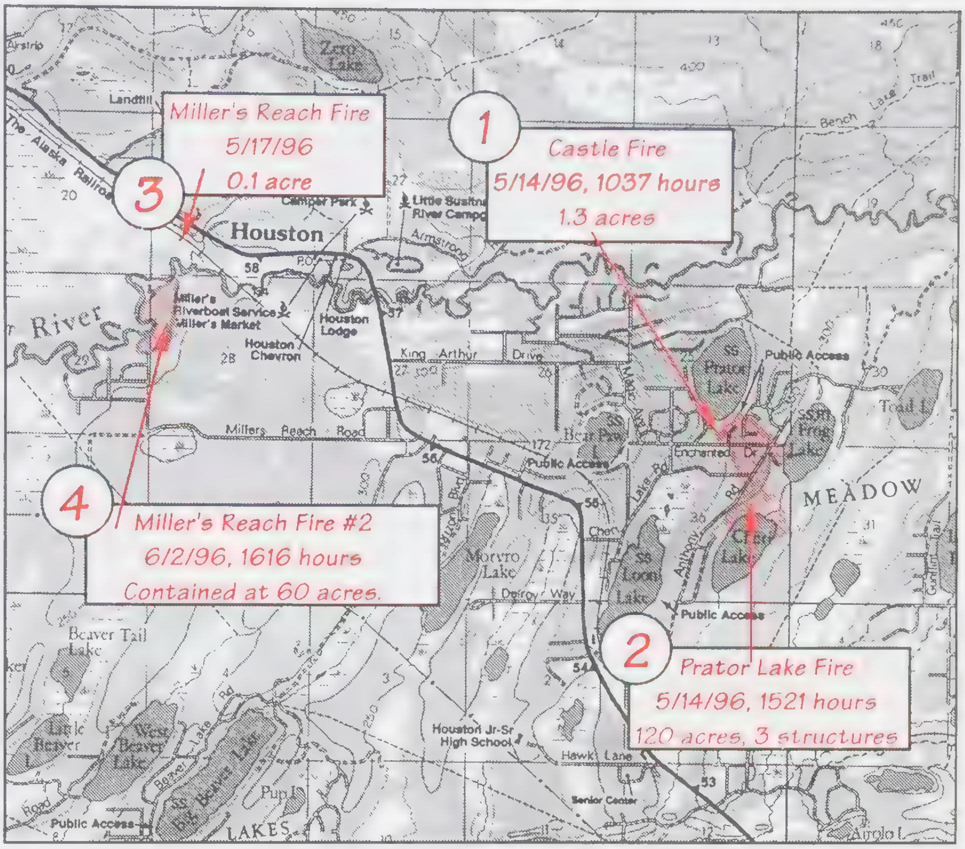
Fire season is set by state statute to run *"from May 1 to September 30."* But, on April 12, the Division had its first fire. They had 40 fires in April, twice the normal fires for this time of year. The weather gave firefighters a little break, but in May the Division averaged five to six fires a day; initial attack forces had to be augmented regularly—an indicator of above-normal burning conditions.

By May 8, Division firefighters had already responded to 79 fires, well ahead of average for this time of year.

The winter was dry; fire season started early.

In mid-May there was a series of suspicious fires near Houston. The fires of real concern occurred on May 14, near Prator Lake. The first fire that day started about 1030 hours; it was controlled at 1.3 acres. Five hours later, a new fire of suspicious origin started. That fire burned 120 acres and destroyed three homes (Figure 5.44). At the same time, there were other fires burning in the state. A fire near Skilak Lake burned 4,000 acres; a fire near Afognak was contained at 1,500 acres. On May 15, the State Forester issued an order to stop debris burning in most of south-central Alaska until the weather changed. (This order was lifted on May 22.)

Two days later, on May 17, another fire started in the Houston area along the railroad tracks. It was quickly controlled. This fire was named Miller's Reach because of its proximity to Miller's Reach Road.


Zero Lake
Airstrip
Landfill
The Alaska Railroad
Houston
Camper Park
Little Susitna River Camp
Armstrong
River
P.O.
Miller's Riverboat Service & Miller's Market
Houston Lodge
Houston Chevron
King Arthur Drive
Millers Reach Road
Bench Lake Trail
Prator Lake
Public Access
Magic Ave
Bear Paw
Enchanted Dr
Frog Lake
Toad L
MEADOW
Craft Lake
Loon Lake
Lake Rd
Anthony Rd
Morvro Lake
Delroy Way
Public Access
Beaver Tail Lake
Little Beaver
West Beaver Lake
Big Beaver Lake
Pup L
Public Access
LAKES
Houston Jr-Sr High School
Hawk Lane
Senior Center
Airolo L

1 Castle Fire 5/14/96, 1037 hours 1.3 acres

2 Prator Lake Fire 5/14/96, 1521 hours 120 acres, 3 structures

3 Miller's Reach Fire 5/17/96 0.1 acre

4 Miller's Reach Fire #2 6/2/96, 1616 hours Contained at 60 acres.

Figure 5.44 A series of fires near Houston concerned firefighters. The Prator Lake fire on the afternoon of May 14, destroyed three homes.

On the morning of June 2, the weather was predicted to be near normal with temperatures in the 60s and relative humidities between 30 to 40 percent. Because of the fire danger, seven smokejumpers had been positioned at the Palmer Airport. An airtanker was on base at Palmer. Engine and crew staffing were above normal.

The prediction was for routine weather conditions.

> ***WEATHER:*** *The weather forecast issued by the National Weather Service in Anchorage, at 1500 hours, June 2, called for partly cloudy skies, lows in the mid-40s to mid-50s, and winds southwest 10 to 15 mph, then light north winds in the Matanuska and Susitna Valleys. June 3 was predicted to be mostly sunny, with temperatures in the mid-60s to low 70s, with relative humidities of 30 to 40%, and winds light and variable. Outlook for Tuesday (6/3) was for increasing clouds with a chance of showers.*

A little after 1600 hours on June 2, Division personnel overheard the dispatch of city and borough fire suppression forces to a wildland fire near Houston. They were already en route to what was to become Miller's Reach Fire #2, before the Division's dispatch center at Big Lake alerted them to respond to the fire.

A full first alarm assignment was dispatched.

1616 hours - A local citizen called the Division's Big Lake Dispatch Office to report a large column of smoke, possibly near Houston. Two minutes later, the local government fire dispatch center received a report of heavy smoke east of Houston, near milepost 57 on the George Parks Highway.

1620 hours - The Division dispatched Engine 440 (with two firefighters) from the Work Center, as well as Engine 461 (with three firefighters) and Copter 523 (with four firefighters) from Palmer Airport. The borough dispatch center dispatched several engines, water tenders, and officers.

When the helicopter lifted off from the airport, the crew leader requested smokejumpers and an airtanker.

1626 hours - The helicopter lifted off from the airport. Two minutes later, after evaluating the rising smoke column, the crew leader onboard Copter 523 asked Big Lake dispatch to put the smokejumpers and airtanker at Palmer on alert.

1642 hours - When Copter 523 arrived at the fire, the helitack crew leader became the initial attack Incident Commander. He reported, "fire is 7 acres in size, south of the Little Susitna River, ½-mile from the highway. One local government engine is at scene and taking action; no structures threatened." He also asked that the seven smokejumpers and heavy airtanker from Palmer be dispatched, and that the air space over the fire be closed to all but firefighting aircraft.

1657 hours - The air space over the fire was closed by FAA Anchorage.

The helicopter was used to drop water on several spot fires across the river.

The helicopter landed to discharge its crew and to set up for using its bucket. One of the first missions for the helicopter was to control several spots across the river. For safety reasons, the helicopter was shut down whenever an airtanker was in the area. This was deemed necessary, but it did cut down on the helicopter's effectiveness. Additional city and borough fire equipment arrived.

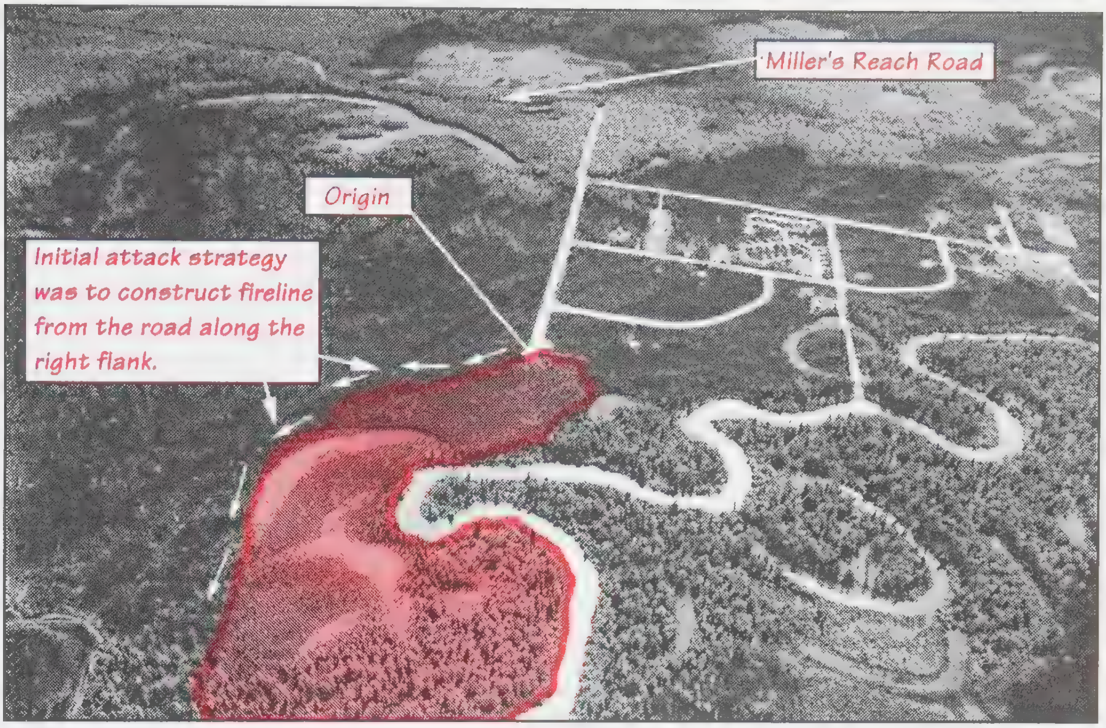

Miller's Reach Road
Origin
Initial attack strategy was to construct fireline from the road along the right flank.

Figure 5.45 The plan was simple: work the right flank, using water supplied by the local government engines, pinching the fire off at the river. The helicopter and its bucket would be used to cool hot spots; the smokejumpers and engine crews would be used to advance the hose lay and construct line. The airtanker drops would be used to support the advancing hose lay.

The suppression strategy was simple: let the fire burn to the less flammable birch/aspen along the river, and anchor the fireline at the cul-de-sac on the end of Miller's Reach Road, by extending a wet line along the right flank, until it tied back into the river (Figure 5.45). A boat was hired from the local marina to facilitate moving forces across the river to the spot fires.

1650 hours - The IC asked that a second airtanker be dispatched and another crew of smokejumpers be moved to Palmer.

1715 hours - Airtanker 161 dropped its first load of retardant on the fire. Air attack instructed Airtanker 161 to "load and return."

1729 hours - The IC asked that two hand crews (Type II) be dispatched.

1809 hours - The IC updated Big Lake dispatch; "jumpers on the ground, hose lays progressing up both flanks; 40% uncontrolled, the head is still moving."

The fire was allowed to run to the river on the left flank; a hose lay was used to control the right flank.

1821 hours - Air attack instructed Airtanker 161 to "load and hold" at Palmer and that Airtanker 97 (the second airtanker from Fairbanks) was to "hold over the fire."

The firefight was going well. There were no structures in the immediate area.

1844 hours - Air attack updated dispatch on the status of the aircraft and the fire. He reported, "the fire is knocked down, and there is no visible flame on the left flank. There are structures 300 yards to the south of the fire. The air attack has been released and is returning to Palmer."

The fire was about 60 acres in size.

1859 hours - The IC reported, "the fire is pushing 60 acres, not completely contained. The east side (right flank) is hot, but knocked down. We need additional personnel." Thirty minutes later, the investigator working the fire told dispatch he suspected the cause to be fireworks.

2040 hours - Most of the city and borough firefighters had been released. The IC had asked that one engine, one water tender, and a service vehicle be kept at the fire to supply water to the hose lays running up the right flank.

2141 hours - The IC informed Big Lake dispatch that he would be bedding the crews in a nearby meadow. He also ordered some overhead personnel, and placed an order for pumps, fire hose, assorted "brass," and chain saws. Twelve minutes later the helicopter was released for the evening.

The firefighters continued to work the fire. One of the hand crews was not used. It was bedded down for the night, so that it would be fresh for the day shift on June 3.

June 3

The personnel bedded down for the night.

0055 hours - The IC briefed Big Lake dispatch on the status of the fire and his plan for the next day. He stated that the fire was contained at about **2200 hours**. However, there were pockets of unburned fuel and there was a spot across the river. He estimated that they would be there for a few days.

At **0214 hours** the IC reported that all personnel were being bedded down for the night, and that local government firefighters had been released to their stations. Several pieces of equipment would return in the morning.

During the early-morning hours, the IC was dealing with logistical issues, lunches, batteries, etc.

0927 hours - The IC reported that the portable pumps had been set up and were in use, and the local fire equipment had been released. The IC requested that the smokejumpers be held for a couple of days.

The firefighters began mopping-up the fire.

> ***WEATHER:*** *The weather forecast issued by the National Weather Service in Anchorage, at 1500 hours, June 3, called for partly cloudy skies, lows in the 40s, and light winds in the Matanuska and Susitna Valleys. Forecast for June 4 was mostly sunny, with temperatures in the upper 50s to low 60s, and northwest winds at 10 to 15 mph.*

The mopping-up of the fire continued. The instructions were to mop up 100 feet back from the fireline.

The winds began to pick up.

1556 hours - The IC reported the winds were beginning to pick up. They were 7 to 10 miles per hour. Ten minutes later he reported that the temperature was 72°, and the relative humidity in the black spruce was 22%. The weather was beginning to change.

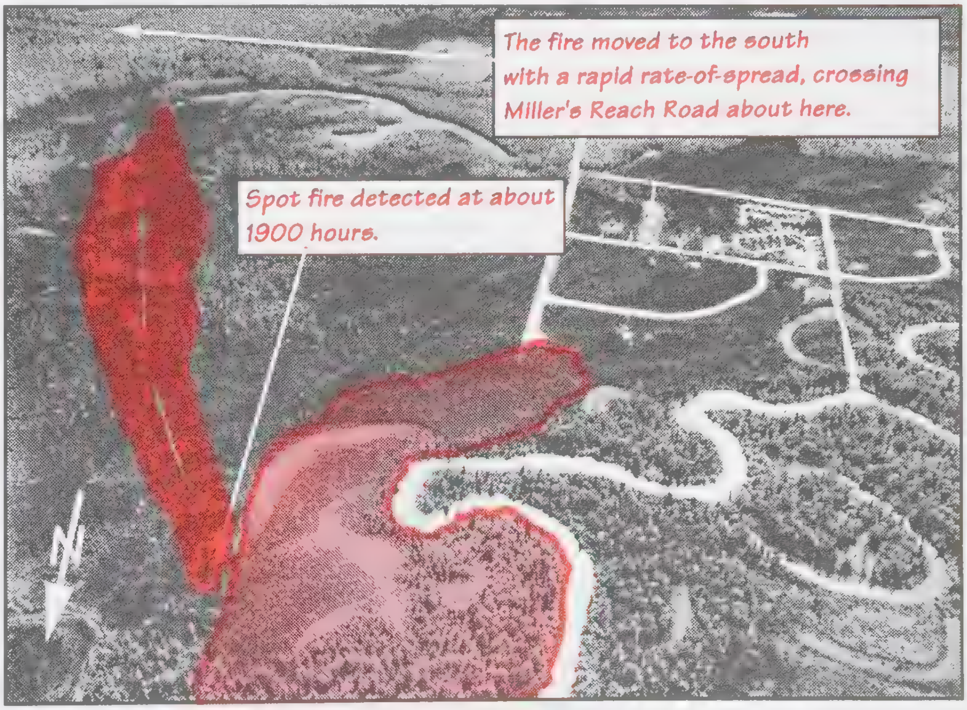

The fire moved to the south with a rapid rate-of-spread, crossing Miller's Reach Road about here.
Spot fire detected at about 1900 hours.
N

Figure 5.46 A gust of wind carried a firebrand across the fireline and started a spot fire. The smokejumpers contained it quickly, but not before another spot fire started farther from the fireline. The northerly winds now pushed the fire into a stage of extreme fire behavior that lasted for several days. The fire started moving through the black spruce toward Miller's Reach Road, ¾-mile to the south.

1915 hours - The smokejumpers found a spot fire across the right flank. The spot was about 25 feet from the fireline. This spot was contained with one hose line. However, it spotted farther to the south, and the new spot wasn't going to be caught for days (Figure 5.46).

The wind was gusting at first. It caused the black spruce to "torch," throwing firebrands into the air.

1918 hours - The helicopter was launched, and two minutes later the two airtankers from Palmer were requested.

1923 hours - The borough dispatch center was notified that the fire had escaped.

The winds were now 30 mph. The fire had escaped and was burning with extreme fire behavior.

1925 hours - The situation was changing rapidly. The IC reported the fire was now burning with extreme fire behavior. It was being pushed by a 30+ mile per hour wind. The IC told Big Lake dispatch that the fire was not road accessible, and that VFD resources were not needed at the time. The Houston Fire Chief returned his equipment to their station, but he continued to the fire. Figure 5.47 shows the fire from the George Parks Highway as it headed south.

1940 hours - The borough dispatch center dispatched a major response to Miller's Reach Road. Within minutes the IC instructed Big Lake dispatch to have Miller's Reach Road evacuated. The State Troopers were notified and were responding.

The local area was evacuated.

The IC met with the Matanuska-Susitna Borough's Director of Public Safety along Miller's Reach Road. They loosely established a Unified Command under the Incident Command System. (They also agreed that they would split up, but remain in communication via the radio.) The plan was to begin evacuation of all the

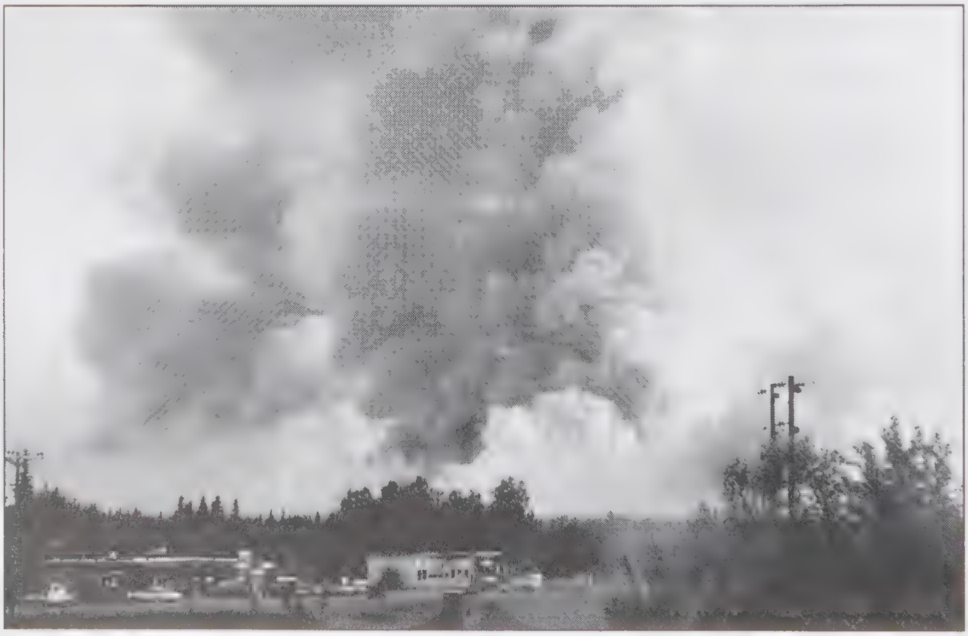


Figure 5.47 The fire was moving south, being pushed by a strong northerly wind.

residences north of Big Lake Road. Within minutes the fire crossed Miller's Reach Road.

2030 hours - The fire was now a very narrow finger of fire burning south toward the north end of Big Beaver Lake, completing a 2½-mile run in about 38 minutes. All the firefighting resources were now actively involved in evacuating people, and attempting to save structures when they could.

The fire moved 2½ miles in 38 minutes.

2300 hours - The fire reached Big Lake Road. This was about 5 miles from the original spot fire. By midnight of June 3, the fire was well across Big Lake Road (Figure 5.48).

Most of the firefighters thought that the winds would die down after dark and that the fire would be controlled at several thousand acres. This is what normally would happen. This would have been the pattern if the winds had been associated with the passage of a front. They weren't! The winds were associated with a gradient, the difference between a high-pressure area located in the north, and a low-pressure area to the south. The winds

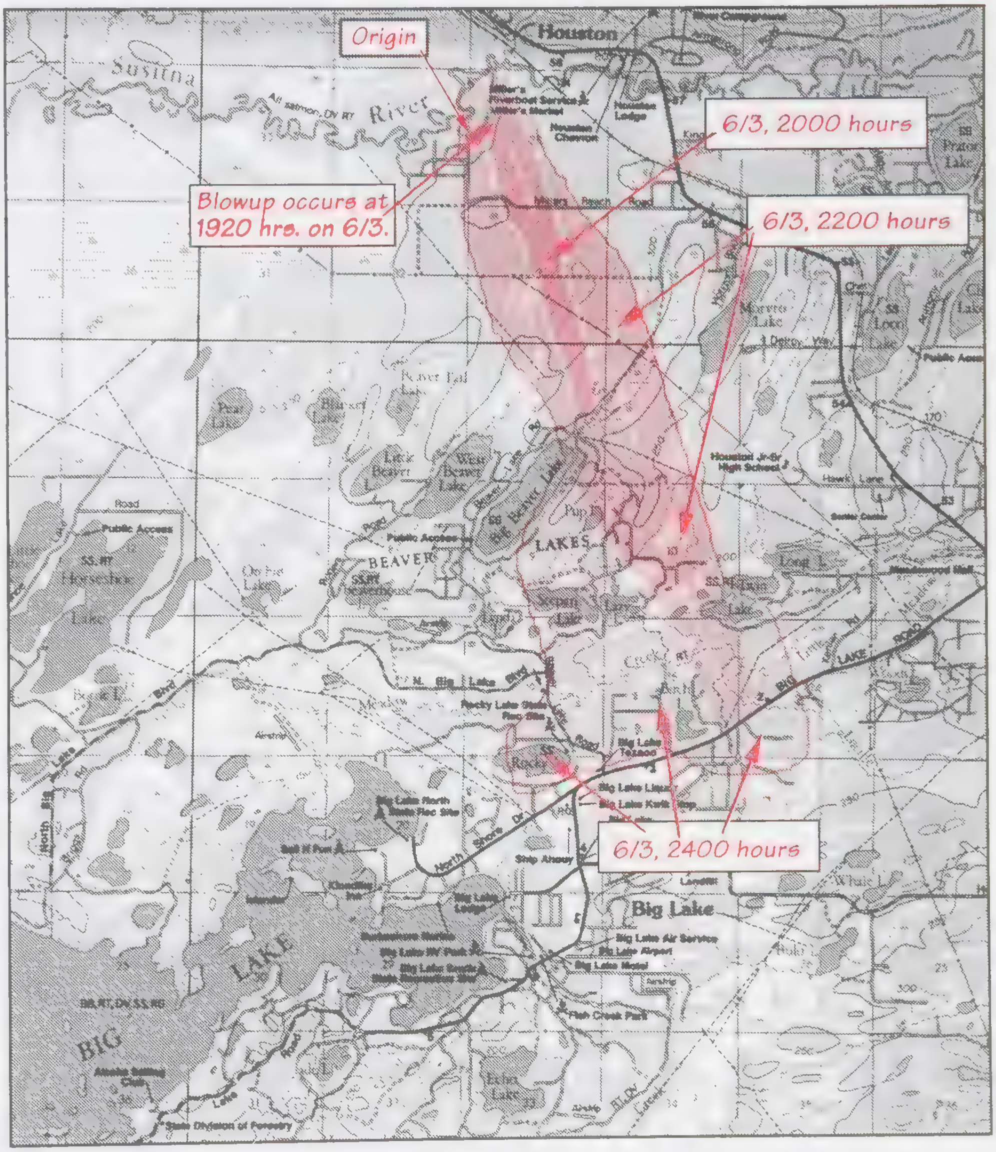

Origin
Houston
Susitna River
6/3, 2000 hours
Blowup occurs at 1920 hrs. on 6/3.
6/3, 2200 hours
Big Beaver Lake
LAKES
BEAVER
6/3, 2400 hours
Big Lake
BIG LAKE

Figure 5.48 The fire was being pushed by a very strong northerly wind. Some firefighters estimate the wind to have been in excess of 50 miles per hour.

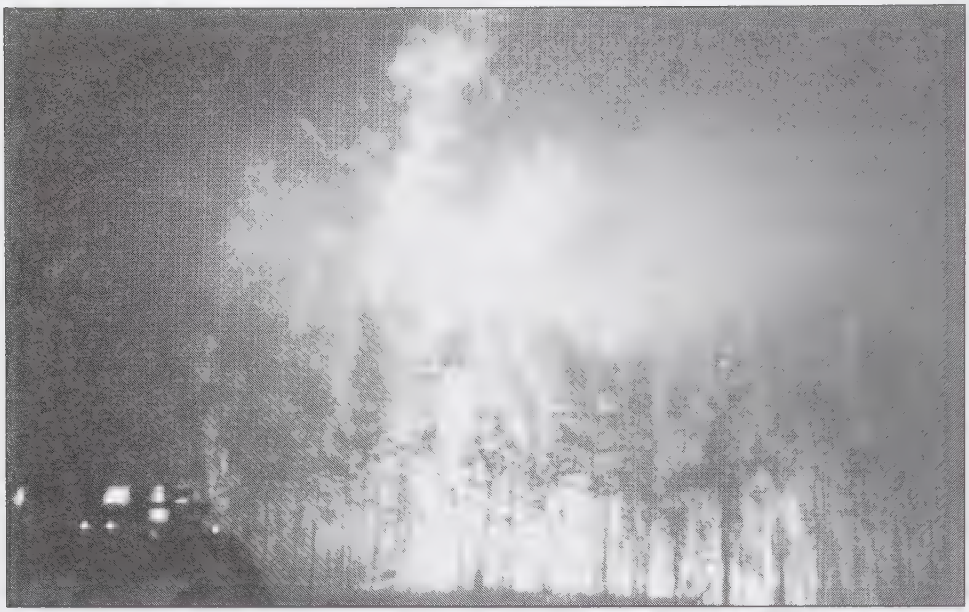


Figure 5.49 The fire hit Big Lake Road about 2200 hours. Fire apparatus were in place, but helpless to do anything. The fire moved on!

would persist until the pressure areas moved or broke down.

When the fire "bumped" Big Lake Road, it did so with flame lengths in excess of 100-feet (Figure 5.49). The sky was red with flame and burning material. Structures were burning.

The two ICs met on several occasions to develop evacuation plans, to deploy forces to protect structures, and to develop plans to begin construction of fireline once the fire slowed down. An incident management team (Type I qualified) had been ordered. An Operations Section Chief of that team was one of the original seven smokejumpers on the fire. He was assigned to begin ordering the necessary firefighting resources.

A Type 1 team was ordered.

At **about midnight**, the wind switched to the east, slowing the southern spread for a time.

June 4

Local government fire apparatus and crews were being moved from Anchorage, Fairbanks, and many other communities throughout the state. Reinforcements were also ordered from the lower 48 states.

Canadian airtankers were moved into the area.

0930 hours - The cooperative agreement between the Division of Forestry and the Yukon Territory was used to move three airtankers to Palmer.

Fire apparatus was positioned at the Houston High School to protect it (Figure 5.50). This would become the incident command post and base of fire operations for the next several weeks.

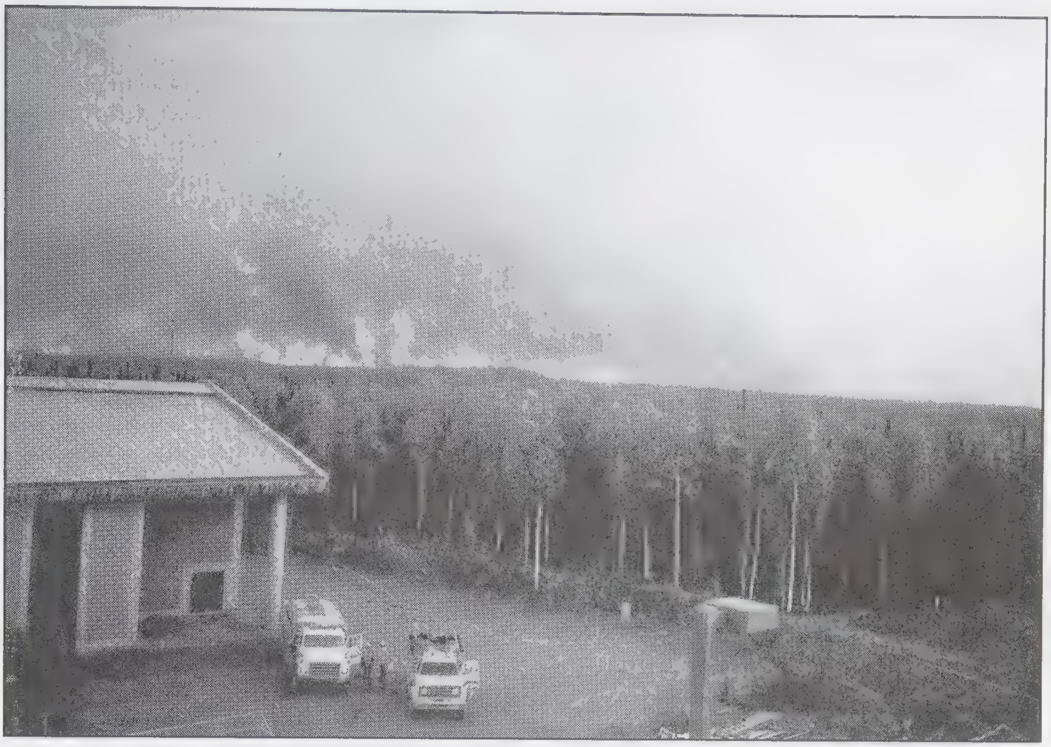


Figure 5.50 The fire moved by the Houston High School on the evening of June 3. On the 4th, the school was directly threatened. The high school was eventually used as the incident command post and base of fire operations.

> ***WEATHER:*** *At 1300 hours on June 4, the National Weather Service in Anchorage issued a red flag warning for gusty north winds, and a drop in the relative humidity to around 17%. The windy conditions would continue until sunset, after which the winds were predicted to drop off, and the relative humidity to recover to around 55%.*

1230 hours - The majority of the Type 1 management team was in place. They assumed command of the fire.

1500 hours - The fire was about 12,000 acres in size, and many structures had been lost. Hundreds of people had been evacuated. The fire was still running. It had moved into several housing tracts and throughout the community of Big Lake (Figure 5.51).

The fire was now 12,000 acres; structures were being lost.

June 5

By morning the fire was moving west toward Horseshoe Lake. The wind was from the east (Figure 5.51). Radio communications continued to be overloaded and practically useless. The

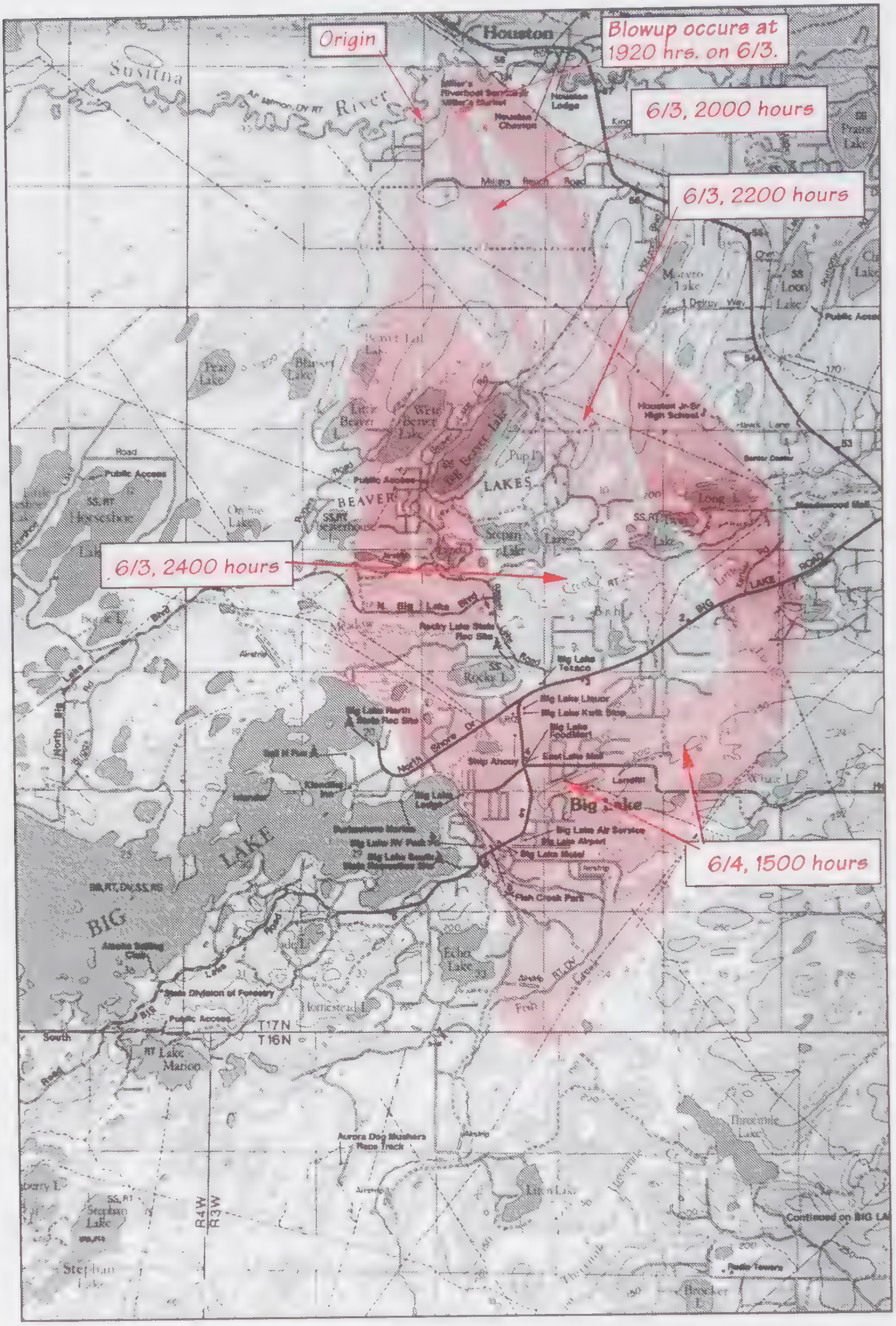

Origin
Blowup occurs at 1920 hrs. on 6/3.
6/3, 2000 hours
6/3, 2200 hours
6/3, 2400 hours
6/4, 1500 hours
Houston
Susitna River
Big Lake
BIG LAKE
BEAVER LAKES
T17N
T16N
R4W
R3W

Figure 5.51 The fire continued to move south. It moved through the community of Big Lake and to the shores of Big Lake itself.

State Troopers continued to move in reinforcements to assist in the evacuation and to control the perimeter of the disaster. Over 50 troopers were assigned to the incident—the single largest mobilization of troopers in the state's history.

The firefight continued for several days. Figure 5.52 outlines the burn pattern for the Miller's Reach Fire #2. Even though the fire was not officially controlled until June 15, the actual progress of the fire was stopped several days before. The fire burned 37,336 acres and destroyed 344 structures.

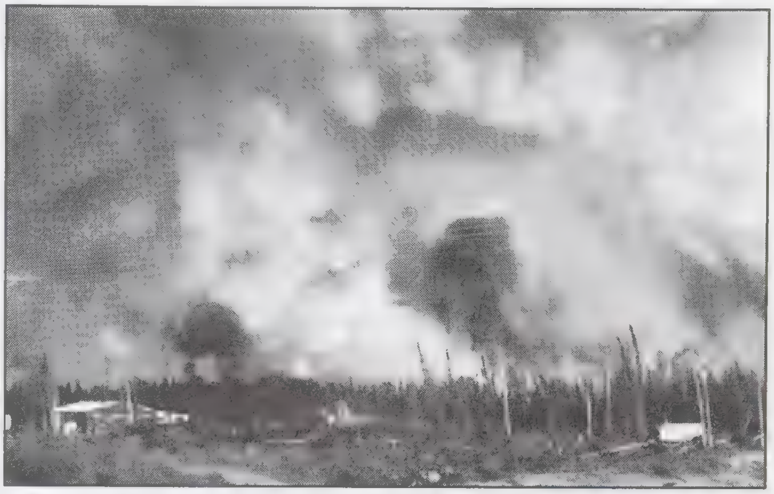


Figure 5.52 The fire continued to move. Some structures were spared if they had adequate clearance. Most were lost because they didn't have defensible space.

What would you do?

As with the Tunnel Fire, once the winds hit this fire, it was going to run until the weather changed. So what could have been done to ensure that the fire did not escape? Not much! Remember, the winds were not predicted, and there was nothing really abnormal about the situation. The forces worked late into the night mopping up. Then they rested, getting ready for the next day's work. They knew they would be there for several days.

This was an unpredicted wind event; what would you have done?

The lessons to be learned here focus on relationships with other fire agencies, and the quick action needed to implement an evacuation. With regard to evacuation, this fire was much different than the Tunnel Fire. During the Tunnel Fire, the fire spread so quickly that it basically engulfed the area, trapping hundreds of people within it. Miller's Reach #2 was more like a knife slicing into the area. Most of those caught by Miller's Reach #2 were those who did not heed the warning to move out.

The Miller's Reach Fire #2 involved extreme fire behavior. What can be learned from this incident? This fire, like any major incident, had problems with radio communications, slow resource arrival, etc. However, most of the criticism focused on relation-

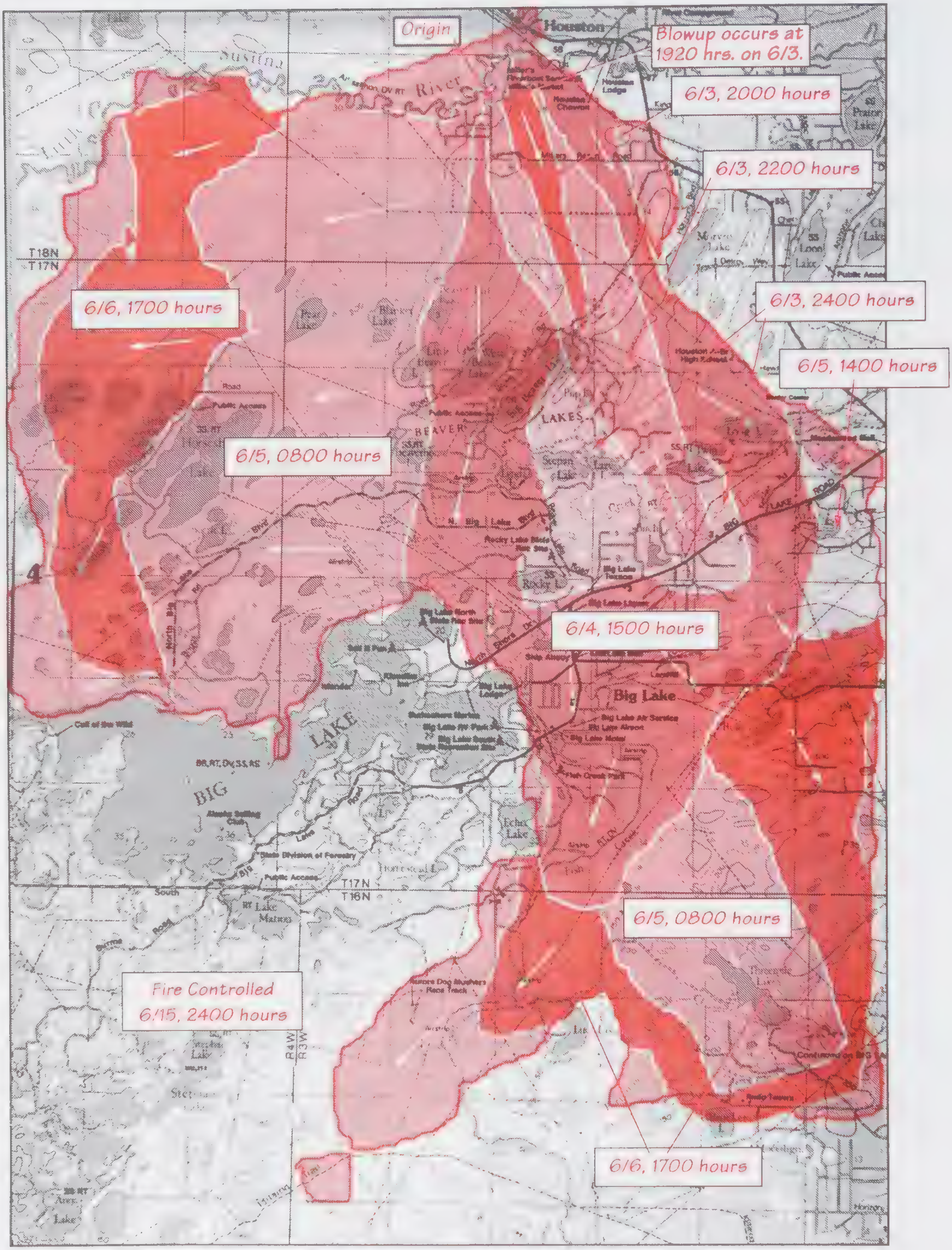

Origin
Houston
Blowup occurs at 1920 hrs. on 6/3.
6/3, 2000 hours
6/3, 2200 hours
Susitna River
T18N
T17N
6/6, 1700 hours
6/3, 2400 hours
6/5, 1400 hours
BEAVER
LAKES
6/5, 0800 hours
6/4, 1500 hours
Big Lake
BIG LAKE
T17N
T16N
6/5, 0800 hours
Fire Controlled
6/15, 2400 hours
R4W
R3W
6/6, 1700 hours

Figure 5.53 The fire spread map for the Miller's Reach Fire #2.

ships with other fire agencies. Relationships with other fire agencies are important to you as a fire officer. You have to understand your agency's authorities and responsibilities. You also have to understand that others may feel they have a role and responsibility that may overlap or conflict with yours. To the extent that it doesn't compromise safety or the success of the operation, accommodate everyone's involvement.

In this particular case, there was some criticism that the agency incident commander turned away assistance from the local fire department, when the fire spotted across lines and escaped. Granted, the fire was in an inaccessible area, and the local engine companies would not have been of any direct assistance. However, the incident commander should have allowed the local forces to assist to their level of expertise and capability, rather than turn them away. Chapter 8 provides a more in-depth discussion of the importance of establishing rapport and mutual respect with other agencies.

How would you have established a better relationship with the local government fire forces?

Notes:

6

Fireline Safety

> ***"...when a crew returns from a fire that has been quickly and efficiently extinguished, the members are likely to be greeted with handshakes, pats on the back, and congratulations for a job well done. Would the same crew be so warmly received if they abandoned a fire that they perceived to be unacceptably risky? If the answer is no, then the unmistakable message that is sent to firefighters is that putting out the fire is the highest priority and that safety, although important, is secondary."*** *Stephen J. Yellstrom, OSHA, Denver Office, following the South Canyon Fire Investigation.*

One of the primary reasons that there are fire departments and firefighters is that the general public doesn't have the training to fight fire safely. They ask you and your fellow firefighters to do this dangerous task for them. **Firefighters are only as good as their training**. Firefighting skills are not hereditary, and they are not instinctual; they are learned. And, we learn by study and practice—a lot of practice**. Learning to fight fire safely is no accident** (Figure 6.1).

Why all the practice? The dangerous nature of firefighting means that you will, at times, be functioning under stress, and may even be downright scared. As stress and fear levels increase, your decision making capabilities narrow, and the subconscious mind begins to make decisions. If you haven't been properly trained, your subconscious mind will not know how to react in an appropriate and safe manner.

There are many examples of this phenomenon. Several years ago, four law enforcement officers involved in a "shoot out" were killed. During the investigation, it was found that the dead officers

In this chapter, you'll

- *Learn that safety is no accident.*
- *Learn that you must fight as you train and train as you fight.*
- *Learn why the* ***Fire Orders*** *are not working.*
- *Learn to appreciate the reason behind each of the 18 situations that shout "watch out!"*
- *Learn that there are many hazards that threaten firefighters.*
- *Learn the do's and don'ts of fire shelter use.*
- *Gain an appreciation for the hazards of fighting fire in the wildland/urban interface.*
- *Learn the role of a safety officer.*

saved their "brass" or spent cartridges, when they reloaded their weapons. This is because they were trained on the range to put their spent cartridges in their pockets or in a can to keep the brass from getting dirty. During the "shoot out," they functioned as they trained. They died with the spent cartridges either in their pockets or in their hands. There have been examples in the fire service where firefighters continued to carry their hand tools or chainsaws even when there was extreme danger, and flight was the only prudent action. Research shows that you can move 20 percent faster if you are not packing your gear or tools. This drives us to ensure that we follow the motto of the Navy's Top Gun pilots, **"You train as you fight; you fight as you train"** (Figure 6.2).

Figure 6.1 Fighting fire safely is no accident. Do you think this firefighter knows what that means?

Safety Zones and Escape Routes

A **safety zone** is an area where you can seek refuge from the fire, smoke, and heat, without the use of a shelter. Some examples of safety zones include: large natural areas devoid of fuels; lakes, ponds, creeks, or rivers; clear-cut blocks, and dozed or plowed areas; and large knobs, wide ridges, and burned-over areas that are cool and relatively free of smoke. Often you hear of firefighters retreating to a safety zone and having to deploy their shelters. By definition, what they were in was actually a survival zone. These are areas where you can expect no flame contact or prolonged heat or smoke. However, the use of a shelter is necessary. If the area was a true safety zone, shelters would not be needed (Figure 6.3). An injury zone is defined as an area where flame contact is expected. Injury may occur even if a shelter is deployed. A dead zone is an area where there will be concentrated heat or the likelihood of prolonged flame contact. Survival is unlikely even with the use of shelters. Insist on nothing less than safety zones.

There are no set rules for the size of a safety zone. The size is dictated by the predominant fuel type, topography, and expected fire behavior.

"See, right here on page 21...that should not be doing that!"

Figure 6.2 What do you think would happen if our firefighter only trained by doing paper exercises?

Escape routes are the paths, trails, or route you will take to get from the place of danger to the place of safety (Figure 6.4). Design your escape strategy so you are able to move quickly from your position on the fireline to a safety zone. Have at least two routes planned. You can never tell when the primary route will be cut off by the fire or other obstruction. The escape routes should be clearly marked and free of material that will slow the movement of personnel. In addition, identify survival or injury zones where you may be able to deploy your shelter and seek refuge if conditions deteriorate quickly.

Once you detect that you may be in trouble, time is critical. You need to have enough time to notify people and get them moved to the safety zone. If the situation is worse than predicted, you had better have enough time to deploy shelters and prepare for the burnover.

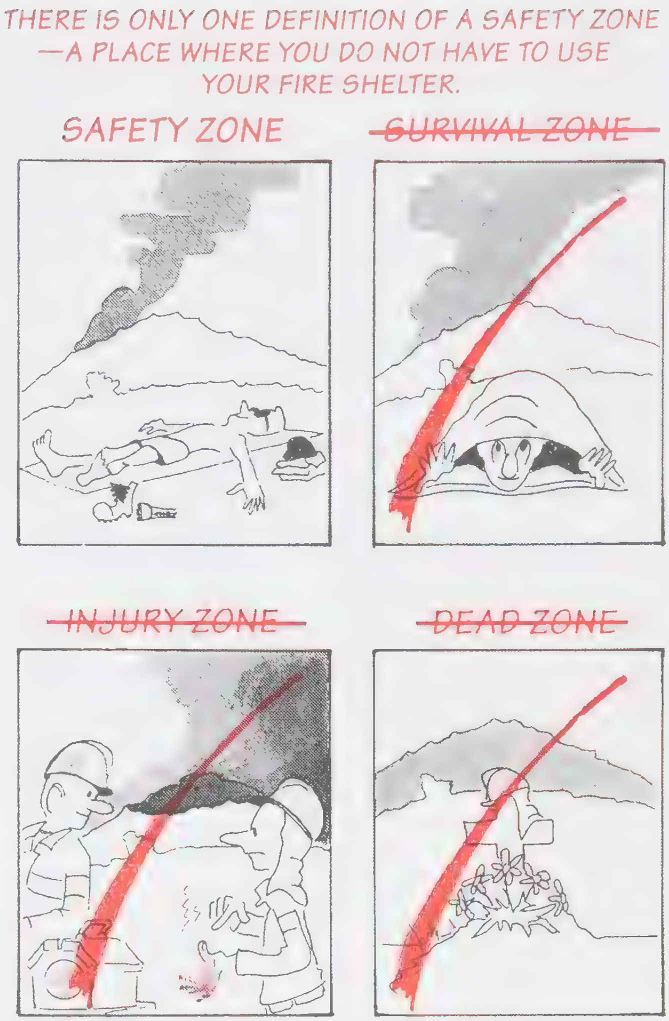

THERE IS ONLY ONE DEFINITION OF A SAFETY ZONE —A PLACE WHERE YOU DO NOT HAVE TO USE YOUR FIRE SHELTER.
SAFETY ZONE
~~SURVIVAL ZONE~~
~~INJURY ZONE~~
~~DEAD ZONE~~

*Figure 6.3 There is only one definition of a safety zone—a place where you can find safety **without** the use of fire shelters. The size, placement, fuel type, and fire behavior all play a part in the definition.*

Why the Ten Standard Orders are not working.

The Standard Fire Fighting Orders, as they were originally called, were issued to USDA Forest Service employees on June 28, 1957, by the Chief of the Forest Service, Richard E. McArdle (Figure 6.5). These orders were developed by a task force, established by the Chief, to study ways they could strengthen efforts to prevent firefighting fatalities. This task force studied 16 fires on which 79 firefighters had been killed. These basic safety orders have been required training ever since they were first issued. Why, then, have hundreds of firefighters been killed or seriously injured despite their training? What has gone wrong?

The Fire Orders were first issued in 1957 after a series of fatal fires.

The orders are now called Fire Orders because it provides an acronym which makes them a little easier to remember. However,

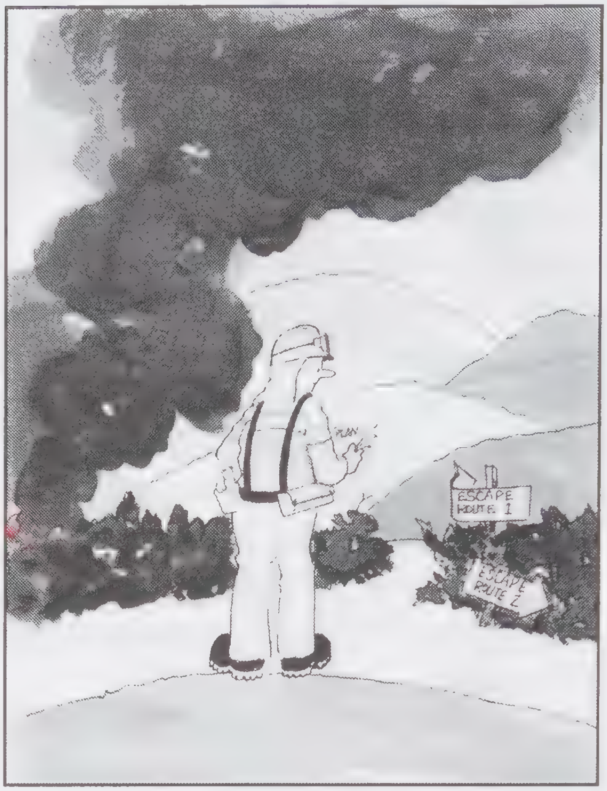


Figure 6.4 Escape routes should be easily identified and clear of hazards that will hinder movement.

some people feel that changing the order in which they are presented just to make them easier to remember was a mistake. The issue is not remembering them, but understanding what they mean and following them. By changing the order in which they are presented, we may have lost sight of how each one ranks in importance and how they ultimately impact one another. The old Standard Fire Fighting Order 1 addressed the need to understand fire weather. It is not an accident that this order was originally the first one listed.

Have at least two escape routes in your plan.

The Fire Orders should not be compromised.

The Fire Orders address safety issues that are not meant to be compromised (Figure 6.6). They are intended to be absolute! Some say that you can't fight fire without "breaking" one or two of them. But, which ones? When? There used to be signs along the highways of this country that said, "You may only need your seat belt once, but which once?" The same applies to the Fire Orders. How do you determine when you can ignore one or more fire orders without disastrous results?

The Fire Orders are not "broke," they just aren't being followed.

The Fire Orders are simple, easy to understand, and easy to remember. Some say the orders and "Watch Outs!" are ineffective! **The Fire Orders are not ineffective—they are just not being followed!**

Studies have shown that we, as a society, don't like to follow orders. The two most commonly violated laws are probably speeding and jay walking. We find it very easy to violate these rules; some firefighters apparently find it very easy to violate the Fire Orders.

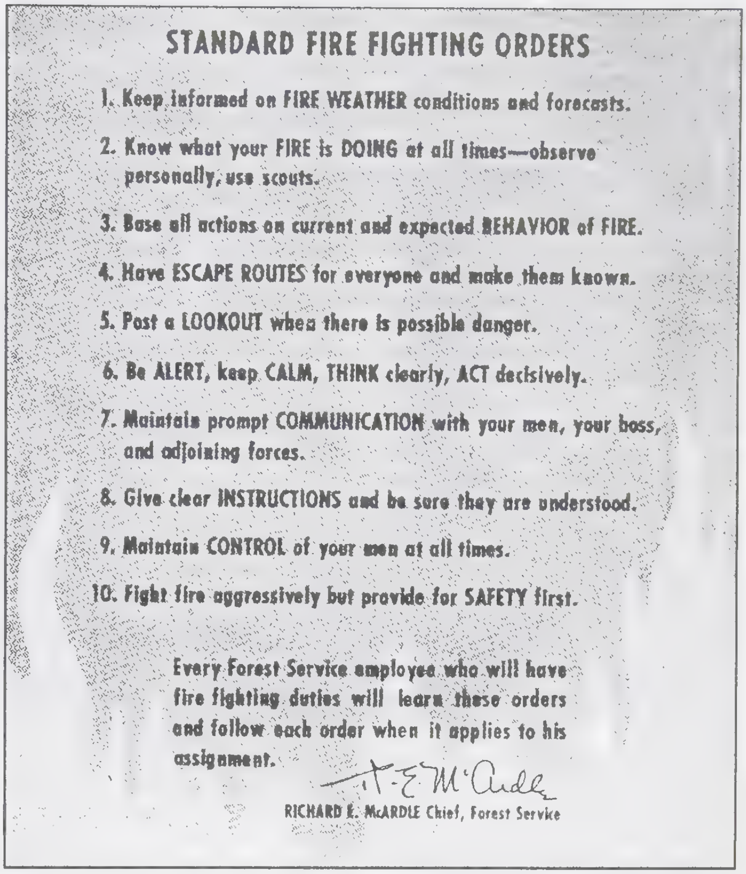
There are a number of reasons that we routinely violate these rules. Following are three of the most common:

Ignorance (or lack of training)- When you have not been adequately trained to recognize potential problems and to respond appropriately.

Machismo (or an excessive "can do" attitude)- When you feel you are immortal and nothing can hurt you! You are overconfident and feel you can extricate yourself from any situation.

Apathy (or lack of empowerment) - When you think someone else will take care of you, or it isn't your job to question violations.

You must understand how ignorance, egotism, and apathy will affect you and those around you.



STANDARD FIRE FIGHTING ORDERS

1. Keep informed on FIRE WEATHER conditions and forecasts.
2. Know what your FIRE is DOING at all times—observe personally, use scouts.
3. Base all actions on current and expected BEHAVIOR of FIRE.
4. Have ESCAPE ROUTES for everyone and make them known.
5. Post a LOOKOUT when there is possible danger.
6. Be ALERT, keep CALM, THINK clearly, ACT decisively.
7. Maintain prompt COMMUNICATION with your men, your boss, and adjoining forces.
8. Give clear INSTRUCTIONS and be sure they are understood.
9. Maintain CONTROL of your men at all times.
10. Fight fire aggressively but provide for SAFETY first.

Every Forest Service employee who will have fire fighting duties will learn these orders and follow each order when it applies to his assignment.

R. E. McArdle

RICHARD E. McARDLE Chief, Forest Service

Figure 6.5 The Ten Standard Firefighting Orders as they were issued by the Chief of the Forest Service on June 28, 1957.

Fighting fire is a lot like driving a car. When you get into your car, you usually have some idea where you are going and the route you will take. In firefighting, this is called your objectives and your plan. You use maps in driving, and you should use maps in firefighting. As you drive down the road, you watch for hazards and signs that indicate when to stop, slow for a curve, how fast you are allowed to go, and detours. In firefighting, you look for changes in weather, fuels, or topography. Your observations may cause you to change your route (strategy) or how you are driving (tactics).

Then there is the Vehicle Code that gives you the rules of the road. In firefighting, these are called the Fire Orders. As a driver, you are required to take a test in order to secure a driver's license. A booklet is provided so that you can study for the test. You also have manuals and tests in firefighting.

The main difference between driving your car and fighting a fire is the development of conscious and subconscious skills. You usually drive on a daily basis, learning and practicing all the time. You allow your subconscious to do a lot of the work. When was the last time you consciously thought about putting your foot on the brake to slow down? Your brain detects the need to slow, but

10 STANDARD
FIRE FIGHTING ORDERS

Figure 6.6 The fire orders are intended to be the "commandments" or basic rules of wildland firefighting. Understand what they mean.

your subconscious moves your foot and applies the brakes. When is the last time you spotted a danger sign and took the time to pull out your copy of the Vehicle Code or DMV guide book to look up what you are supposed to do? You would be dead or injured before you found the answer. Yet, we rely on printed copies of the Fire Orders and the 18 situations that shout "Watch Out!" to bail us out on a wildland fire. So, the real difference between driving and firefighting is that we practice driving daily, while most of us do not train for firefighting in such a way that we "train" the subconscious to do some of the thinking for us.

You train to learn skills. You train to ensure that the skills become automatic. You train to develop a team. There is a saying, "Practice makes perfect." A more practical saying for a fire officer should be, **"Practice makes responses instinctive."**

Let's take each of the orders and dissect them in an attempt to learn their meaning, purpose, and importance to you as a fire officer.

Fighting fire is like driving a car!

Practice makes perfect. It also makes responses instinctive.

FIGHT FIRE AGGRESSIVELY, BUT PROVIDE FOR SAFETY FIRST.

This order is a general statement that says that you should take meaningful and bold actions to fight the fire, but do so safely. If you follow the next nine orders, you will comply with the first (Figure 6.7).

What this means is, if you can't attack the fire with some effectiveness, don't attack it until

F
Fight fire aggressively, but provide for safety first.
Fire Orders

Figure 6.7 Fight fire aggressively, but provide for SAFETY FIRST.

you have the force and skills available to do so. Don't just start "whaling" at the flames because you are there. Do so in a manner that is meaningful.

This order also says that you must "provide for safety first." How can you do this when fighting fire is inherently unsafe? You can do this by being smarter than the fire. You should know what the fire is going to do before it does it. You know what you and the firefighters with you are capable of doing. And, you should ensure that you have more force than the fire either has or will have, and that your plan takes into account potential safety issues.

Before you can fight fire aggressively and provide for safety first, you must have a plan.

If you can't ensure that you and your force are capable of fighting the fire on your terms, back off and develop another plan. Ask yourself, "Do I have the forces, skills, and tools necessary to safely control this fire"? If not, change your plan.

Do not consider review of the Fire Orders as something you do only once when you first arrive at the fire. You must constantly review them, if for no other reason than to help you detect changes and/or the unexpected.

INITIATE ALL ACTIONS BASED ON CURRENT AND EXPECTED FIRE BEHAVIOR.

If you can't predict what the fire is going to do, how can you develop a meaningful plan to attack it? What makes this order hard to follow is that you must continuously evaluate the fire behavior and detect subtle changes (Figure 6.8). Is the fire doing what you thought it would? If not, why? Some of the factors that you must continuously review are:

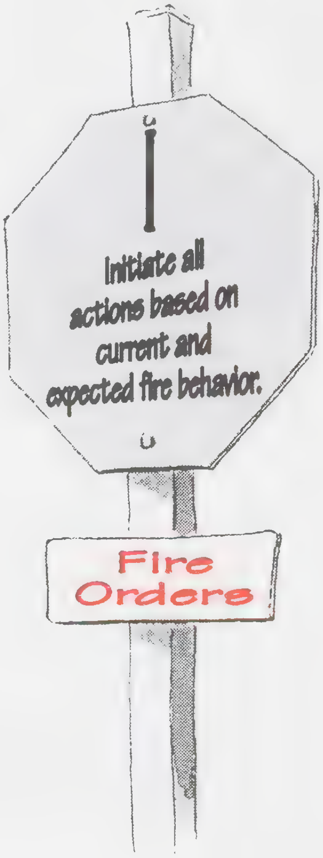

Initiate all actions based on current and expected fire behavior.
Fire Orders

Figure 6.8 Initiate all actions based on current and expected fire behavior.

Weather - Is the weather what was predicted? Has it changed? Do you expect it to change? How will these changes impact the fire and your firefighters?

Topography - Is the fire moving into areas with different topography? What will this mean, and how will you have to adjust your plan to accommodate these changes?

Fuels - Are the fuels of such a nature that they will support fire behavior that will make your present plan invalid? Is the fire moving into heavier fuels, and can you prevent it?

Time of day - Is the heat of the day still ahead of you? If so, what can you expect to happen in a couple of hours? What changes in temperature, relative humidities, and winds can you expect later in the day/night, etc.?

If you can't ensure the safety of you and your crew, you are violating a Fire Order.

Make an effort to plot your fire behavior predictions on a map. Then check to see "how you did" in estimating the rate-of-spread. As you are plotting things on the map, be sure to indicate time frames as well. Keep track of when the fire reached each location, when it spotted, when you implemented specific suppression activities, etc. That way you will be able to spot gaps in your plan.

Weather and fire behavior are interrelated.

RECOGNIZE CURRENT WEATHER CONDITIONS AND OBTAIN FORECASTS. This is probably the most important of the ten Fire Orders. There are two types of weather information: tactical and strategic (Figure 6.9).

R
Recognize current weather conditions and obtain forecasts.
Fire Orders

Figure 6.9 Recognize current weather conditions and obtain forecasts.

Tactical weather is the weather on the fire.

The primary reason to record weather readings is to detect change.

Tactical weather information is weather that is taken and recorded at the scene of the fire. It includes the temperature, relative humidity, and wind speed and direction that you measure and record at regular intervals during the life of the fire. Remember, the primary purpose in recording weather is to enable you to detect changes, and you can only detect changes if you have data to compare with. When you record the weather readings, you should also make notes as to the state of the fire behavior. Note the flame length, color of the smoke, the ease or difficulty of control, and local wind patterns. This will allow you to start developing an understanding of fire behavior under differing weather conditions.

You may want to use off-site weather information to supplement your own weather readings. There may be a lookout that takes weather readings. Ask for the readings and record them. If you expect a weather change, like one that may be tied to the passage of a cold front, get weather readings from a station some distance (10 to 20 miles) away, so that you can get a "jump" on the pending change.

Strategic weather is the general weather for the area.

Strategic weather information is the information you receive from a weather forecast. It is of a general nature that provides weather trends (e.g., temperature up 7°, relative humidity down 5 to 10 percent). You can use this data to predict the expected tactical weather information. That, in turn, will aid in the development of your fire behavior predictions.

To comply with the Fire Orders, you have to know both the tactical and strategic weather.

To comply with this Fire Order, you must take the weather on site, and ask for a forecast if you don't remember the one issued earlier. You might question the need to track the weather on a small fire that will be controlled within a few minutes. However, it can help you identify why the fire is just a spot, rather than halfway up the hill. And, it's a good opportunity to practice your skills in a relatively calm situation. Get into the habit of tracking the weather.

ENSURE INSTRUCTIONS ARE GIVEN AND UNDERSTOOD.

If fire personnel don't know what is expected of them, how can they effectively contribute to the overall plan of attack? If you are the fire officer briefing your subordinates, be clear and concise in your communications. Have your subordinates repeat the instructions if you are not totally sure they understand them. If you are the one receiving the instructions, make sure that you know what they mean (Figure 6.10).

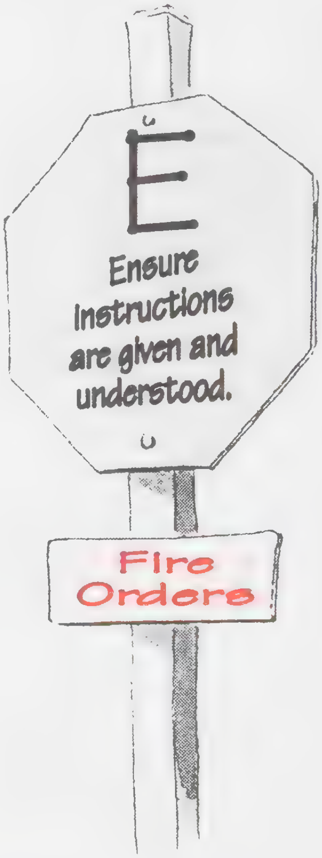

E
Ensure instructions are given and understood.
Fire Orders

Figure 6.10 Ensure instructions are given and understood.

This Fire Order is directed at all fire personnel. EVERYONE on the fire is giving or receiving orders. Ensure that instructions are given to, and understood by, all. Then follow-up to ensure compliance.

If you don't know what the fire is doing, you are in violation of a Fire Order.

OBTAIN CURRENT INFORMATION ON FIRE STATUS.

You can learn a lot about the fire status by listening to the radio as you respond. Some of this information will have to come from your supervisor, or it may have to be gathered by you during your initial sizeup of the fire (Figure 6.11). You should know the direction and rate-of-spread; the location of existing fireline, breaks in fuels, or natural barriers; type and status of the fuels; fire behavior and problems with spotting.

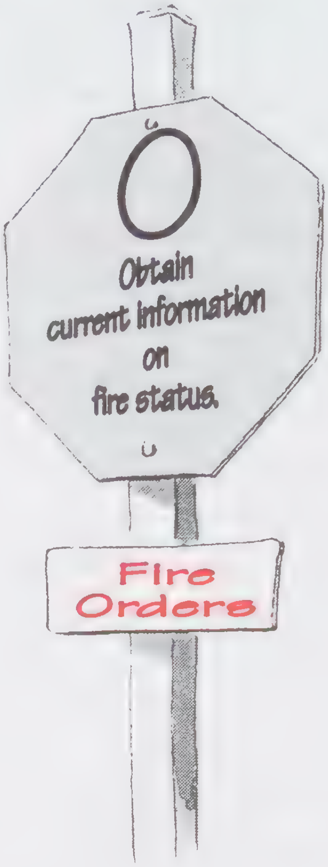

O
Obtain current information on fire status.
Fire Orders

Figure 6.11 Obtain current information on fire status.

How can you develop a meaningful plan if you don't know what you are fighting?

If you can't determine this information by personal observation, send someone out to get it (a scout) or ask someone (supervisor, air attack, or lookout). If that's not feasible, you will have to get the information yourself. If you think you can get away without having current information on fire status, you will not be in compliance with this Fire Order, and you will not be able to develop a safe, effective plan of attack.

You must have contact with your crew, your supervisor, and those around you.

REMAIN IN COMMUNICATION WITH CREW MEMBERS, YOUR SUPERVISOR, AND ADJOINING FORCES.

You must maintain communications with your crew members, your supervisor, lookouts, and adjoining forces. The purpose of this fire order is to ensure that you can give or receive changes in instructions, warnings of changing conditions or pending danger, changes in status, or progress reports (Figure 6.12).

If you are going to rely on a radio as your communications link, make sure that you have tested the link, have an extra set of batteries, and have established check-in times. You should also

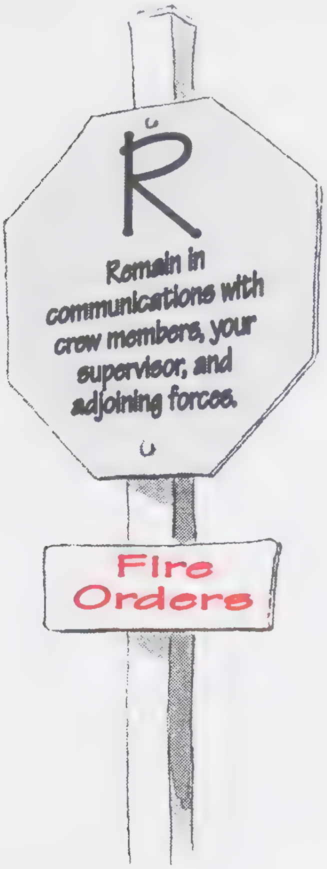

R
Remain in communications with crew members, your supervisor, and adjoining forces.
Fire Orders

Figure 6.12 Remain in communication with crew members, your supervisor, and adjoining forces.

have a contingency plan in case the radio link doesn't work.

If you are not linked with those above or below you in the chain of command, you are not in compliance with this Fire Order.

If you cannot quickly make contact with everyone on your crew or your supervisor, you are in violation of a Fire Order.

DETERMINE SAFETY ZONES AND ESCAPE ROUTES.

As noted on page 286, a **safety zone** is an area that can be used by firefighters seeking refuge from an unexpected change in fire behavior or burning conditions. A safety zone must be void of fuels, such as in the black (as long as all fuels are burned). Other examples are rock slides or outcroppings, green areas (lawns, meadows), or wet areas (lakes, swamps, wide creeks). The key is that it is an area that will protect the firefighters from injury (Figure 6.13). If the area requires the deployment of fire shelters to be safe, it does not technically qualify as a safety zone.

You may have to construct safety zones. You can do this by burning out an area, or clearing a zone with equipment or hand tools. The terrain or fuels may require you to construct several safety zones. The type of fuel, terrain, expected fire behavior, and the number of people the site will have to accommodate, dictate how big the safety zone should be. Remember, safety zones should be so carefully selected and properly prepared that the use of a fire shelter should not be necessary in order to survive.

The distance between safety zones is dictated by how much warning you can expect to get if conditions change, how fast you

D
Determine safety zones and escape routes.
Fire Orders

Figure 6.13 Determine safety zones and escape routes. Make sure that everyone knows where they are located and how to get to them.

think conditions could change, and how fast you can get your personnel notified and moved.

An **escape route** is the way you get you and your personnel from where you are working (and in danger) to a safety zone. Escape routes must allow you to move quickly and safely. Very seldom will a route that takes you uphill qualify as an acceptable escape route. Have two routes selected. That way, if one route is cut off, you still have a way to get to the safety zone.

Stop what you are doing until you have identified two escape routes.

This Fire Order should stop more operations than it has in the past. Safety zones, and the routes to them, are your first line of protection. If you don't feel comfortable with the location or size of the safety zone, or the route(s) you have to use to get to it, change them, or change your strategy and tactics. You may want to hold off working specific pieces of line until the fire behavior is expected to be more favorable; or you may have to move a fireline, or attack the fire from another direction. If you are not comfortable with the safety zones and/or escape routes, you are not in compliance with this Fire Order.

If you are not comfortable with the escape routes or safety zones, you are in violation of a Fire Order.

ESTABLISH LOOKOUTS IN POTENTIALLY HAZARDOUS SITUATIONS.

Lookouts have to know what they are looking for and at.

If you can't see what is happening around you, you must establish a mechanism that will provide timely, accurate, and meaningful information (Figure 6.14). You may be able to rely on aircraft or a nearby lookout, but in most cases, you should assign experienced firefighters to be your lookouts. The lookouts must be knowledgeable in fire behavior, so that they know what to look for and understand the signifi-

Lookouts must have a quick means of communicating with you.

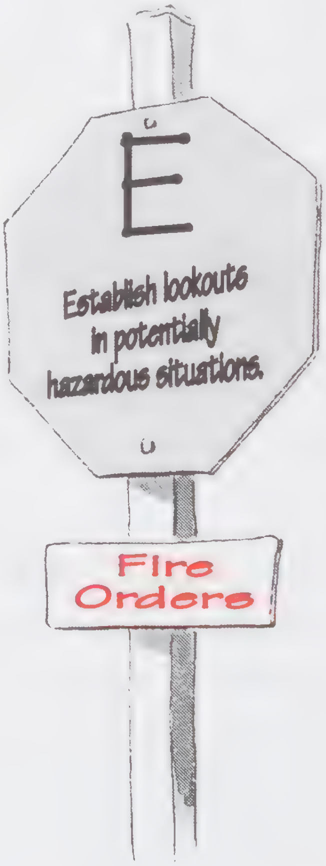

E
Establish lookouts in potentially hazardous situations.
Fire Orders

Figure 6.14 Establish lookouts in potentially hazardous situations.

cance of any changes. They must have a way to communicate with you to provide a warning or to obtain changes in assignment.

Lookouts are a way to take the surprise out of a changing situation. If you don't have a way of keeping informed of changing conditions, you are not in compliance with this standard order.

Lookouts are posted to take the surprise out of changing conditions.

REMAIN CONTROL AT ALL TIMES.

If you, as the fire officer, don't remain in control, how can you expect those below you to do so? The best way to remain in control is to ensure that your instructions are clear, concise, and understood; that you maintain communications; that you know the location of your people; and that you know the status of the fire, and when and how you will move your forces to safety. As the situation worsens, you may want to concentrate your personnel in one area (Figure 6.15).

If you are not in control of your crew, you are violating a Fire Order.

R
Remain in control at all times..
Fire Orders

Figure 6.15 Remain in control at all times.

The key to maintaining control and to be in compliance with this Fire Order, is being prepared to react quickly and effectively to the unexpected.

Have a plan so that you can react to changing events.

STAY ALERT, KEEP CALM, THINK CLEARLY, AND ACT DECISIVELY.

This Fire Order is an extension of the one above. If you comply with this order, you will comply with the previous Fire Order. The key is to understand and avoid what may cause you to be less alert, to get excited, or to become mentally disorganized (Figure 6.16).

Physical and mental fatigue will reduce your ability to think clearly.

Physical and mental fatigue, the stress of the situation, and heat and carbon monoxide will all "gang up on you" during a fire fight. Fatigue will begin to take its toll when you don't eat properly or get regular rest. Heat stress will begin to affect you if you don't drink enough water. Carbon monoxide, a natural product of combustion, can build up in your system to the point where it will reduce your ability to think clearly.

Take breaks to help clear your thoughts.

One of the best ways to avoid these problems is to take frequent breaks from the action when you can. One way to do this is to get away from the radio, face away from the action, and think about anything but the fire. Fishing, hiking and swimming are good! This kind of action provides a "quick charge" to your brain. When working hard, you have to give your muscles a break; when your brain is being taxed, give it a break too. (Warning: Never turn your radio off and cut yourself totally off from communications. Make sure someone nearby is in radio contact with the rest of the world, or you will be in violation of the sixth Fire Order and may put yourself and your crew in extreme danger!)

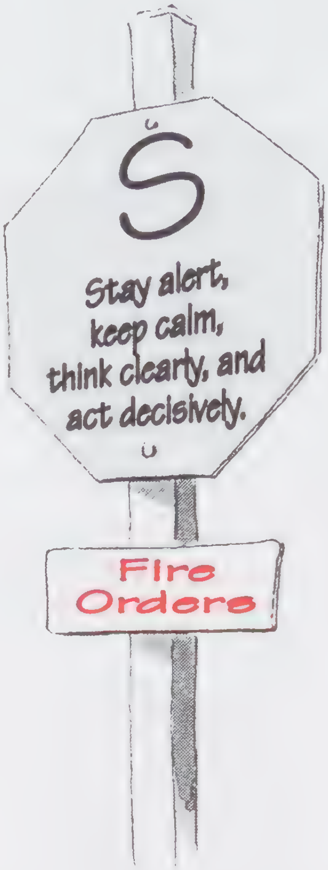

S
Stay alert, keep calm, think clearly, and act decisively.
Fire Orders

Figure 6.16 You have to stay alert and calm in order to be ready to respond to changing conditions.

Lack of adequate food, water and rest will diminish your effectiveness.

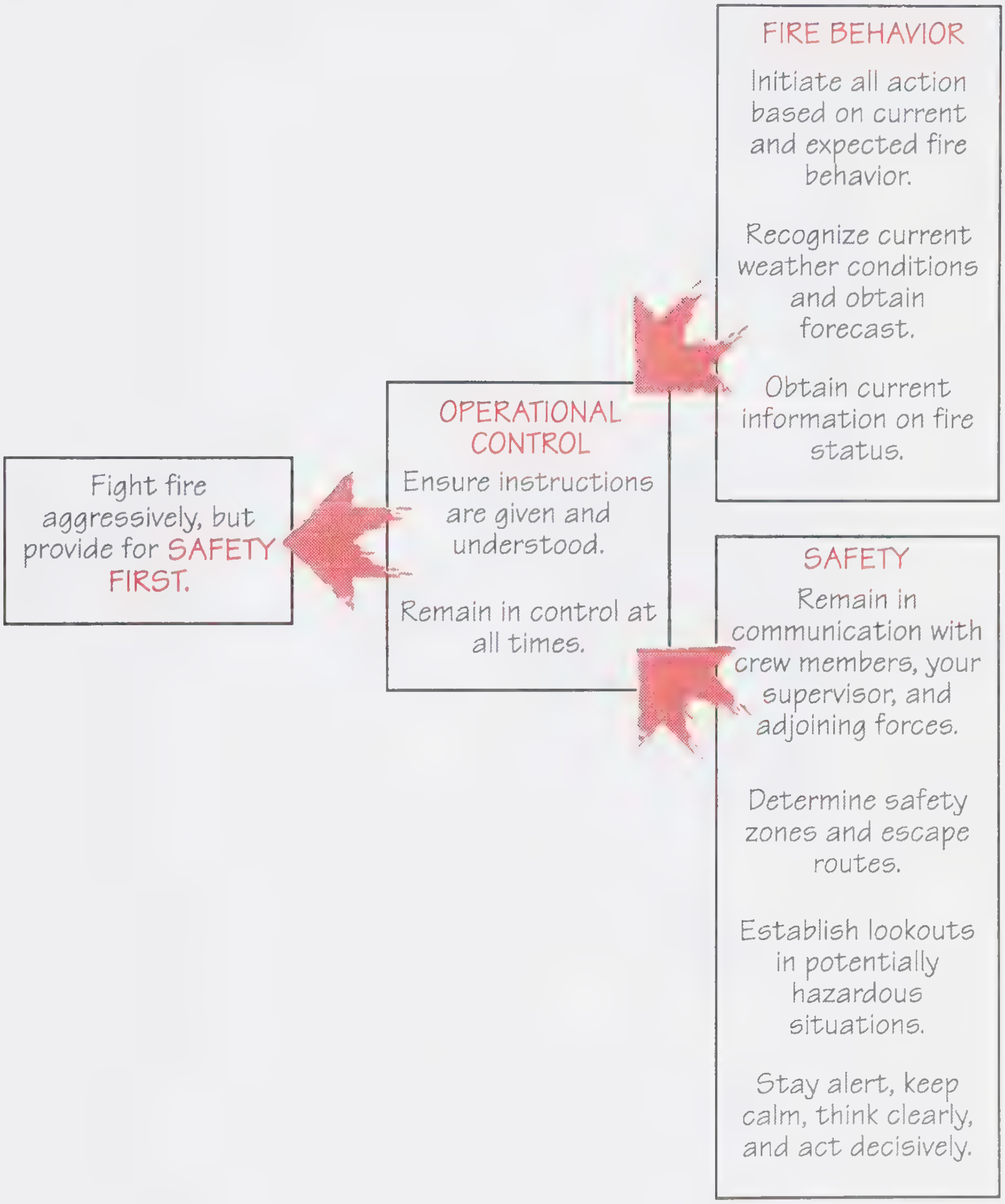
If you are going to be able to effectively deal with the situation, you should:

- Maintain self control.
- Ensure that you get enough to eat and drink, and get adequate rest.
- Develop contingency plans.
- Monitor the situation closely.
- Seek information and advice from others.
- Take regular breaks from the action.

The Fire Orders deal with fire behavior concerns, safety precautions, and operations, all of which are summed up in the first Fire Order: SAFETY FIRST (Figure 6.17).

The Fire Orders deal with fire behavior, safety and operational control issues.

THE FIRE ORDERS and SAFETY FIRST



FIRE BEHAVIOR

Initiate all action based on current and expected fire behavior.

Recognize current weather conditions and obtain forecast.

Obtain current information on fire status.

SAFETY

Remain in communication with crew members, your supervisor, and adjoining forces.

Determine safety zones and escape routes.

Establish lookouts in potentially hazardous situations.

Stay alert, keep calm, think clearly, and act decisively.

OPERATIONAL CONTROL

Ensure instructions are given and understood.

Remain in control at all times.

Fight fire aggressively, but provide for SAFETY FIRST.

Figure 6.17 Think of the Fire Orders in three elements: fire behavior, safety, and operations.

The 18 Situations that Shout "Watch Out!"

The Fire Orders are like the basic rules of the road—you drive on the right side of the roadway; you stop at stop signs; you don't follow too close. The 18 situations that shout "Watch Out!" are more like warning signs; soft shoulders; slow, curve ahead; entering school zone. It is important that you know the meaning of these signs and what to do to neutralize them. Most of the 18 situations tie back to violations of the Fire Orders.

The 18 situations that shout "watch out" are like traffic signs to a driver of a car.

1. **You are on a fire that has not been scouted or sized up**. - You shouldn't begin fighting a fire until you know what you're fighting (Figure 6.18). If you are the first one on scene, you should take the time to size up the situation. If you can see the whole fire from where you are, that's great. But if you can't, you are going to have to maneuver around so that you can see what is happening, or rely on information from others.

One of the best sources of size up information is the air attack. They have a view that is unequaled; use it.

Size up the fire, develop a plan of attack and then take action.

Some of the critical questions to ask yourself are:

- Where is the fire located and what is its size?
- What is the level of fire behavior, and in what direction is it burning?
- What are the present and potential future risks (people, structures, heavier fuels)?
- What are the present and potential future weather conditions?
- What is the topography?
- Are there specific dangers that may come into play such as mine shafts or numerous snags?
- Do I have enough information to formulate a plan?

Figure 6.18 You have no idea what is happening, where the fire is located, or its size!

Once again, if you don't have answers to all of these questions, you will have to rely on others for the information. You should post lookouts to monitor and report on the situation. You should designate and/or establish safety zones and the escape routes you will use. And, if necessary, you may have to back off until you can get the answers to these questions.

If you don't have all of the information you need to be comfortable, ask for it.

2. You are in country that you have not seen in daylight. - Since your size up is made visually, lack of adequate lighting changes everything (Figure 6.19). If you can't see, you can't size up. Your perception also changes at night. Your ability to judge distances is disrupted. The size of the fire will be overestimated and distances will be underestimated.

At night, you will not be able to get all of the information you need to develop a proper course of action. If you can't get the information yourself, or can't get it from others who have seen the area during daylight hours or who know the country, you may have to wait until daylight.

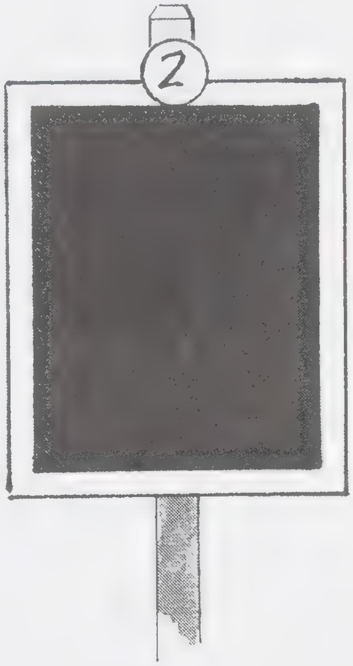


Figure 6.19 It is dark and you can't see a thing!

At night everything looks different. Distances and sizes are distorted.

3. Safety zones and escape routes have not been identified. - This is more than a "Watch Out!" It is one of the Fire Orders. You shouldn't move until this concern has been addressed. The key is to identify the zones, and to determine how you are going to get to them (Figure 6.20). Again, this is a size-up issue that could be handled by a scout. If you are on an engine, you may be able to position the engine such that it can be used to move out of the area.

If you don't have a plan to deal with unexpected changes in fire behavior, you are in danger.

If you are going to have to move off the road, you should have some idea where you are going to go if the situation changes for the worst. ALWAYS have a plan.

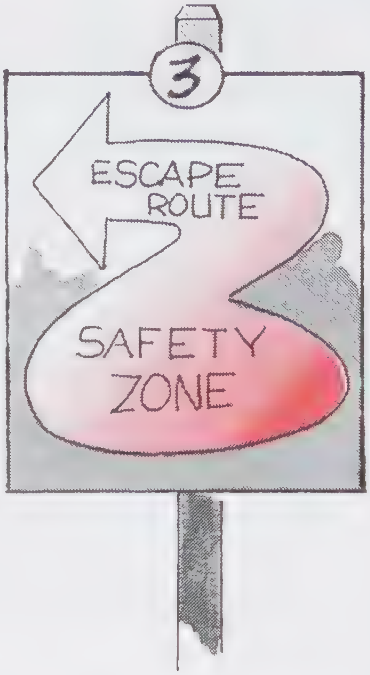


Figure 6.20 You have no idea what you are going to do if the fire blows up.

Ask local firefighters what to expect under certain weather conditions.

4. You are unfamiliar with the local weather and other factors that may influence fire behavior. - An area that is subject to wildland fires has some unique weather patterns and other local influences (Figure 6.21). It may be its proximity to the ocean, strong afternoon upslope winds, a downslope wind from a glacier, or the presence of a pronounced thermal belt. In most cases, these local factors are controlled by how the terrain influences the effects of changing weather patterns. Ask an "old timer" or "local" what to expect if the weather changes. Check the incident action plan to see if it indicates what will be happening. The thrust behind this "Watch Out!" is that things may not happen like they do at home.

Figure 6.21 You have never fought fire in this area before. The cloud patterns indicate that a change is coming, but you have no idea what that means.

Get a sense of the overall plan.

5. You are uninformed regarding strategy, tactics and hazards. - If you don't know the plan, you have no business on the fireline (Figure 6.22). You are putting yourself, your crew, and others on the fireline at risk. There

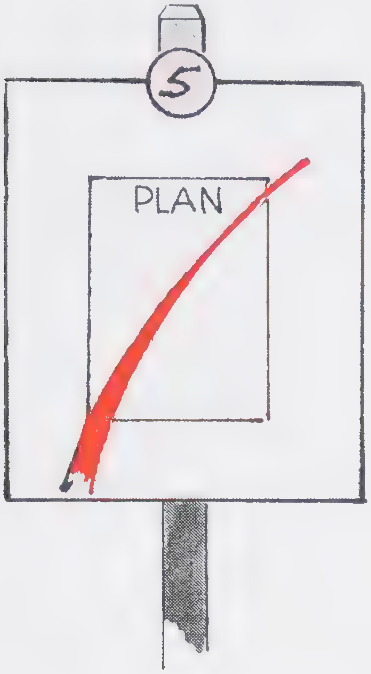


Figure 6.22 You are not sure what the plan is. Are they using a direct or indirect attack?

have been many times when one crew took actions that put others in harm's way. The most dramatic recent example is when one crew was making a direct attack on a flank of the fire, and another was firing out from a road, putting the first crew between the main fire and the back fire.

You must know what is expected of you. Find your line supervisor and get instructions. Ask what your assignment is and how it fits into the overall objectives on the fire. Ask if there are any special hazards either on the fireground or in the weather forecast.

If your instructions are not clear or are incomplete, ask for clarification.

Figure 6.23 "The incident commander told me what to do, but it doesn't make sense."

6. You are not clear on your instructions and assignment. - This "Watch Out!" is similar to the one above. If you are not sure what is expected of you, or if what you were told to do does not match what you see on the fireline, ask for clarification (Figure 6.23). If conditions are changing, or the strategy is changing, you need to know what is expected of you.

You have to have a way to get information and pass it on.

7. You have no communications with your crew members, your supervisor, or adjoining forces. - If you can't communicate with your crew, your supervisor, or

Have an extra set of batteries for your radio.

adjoining forces, you have no way of "knowing about" or "being informed of" changes in plans or dangerous situations that are developing. You also don't have a way to report changing conditions on your part of the line (Figure 6.24).

Radios are the most common way fire officers communicate with supervisors or adjoining forces. Always have an extra set of batteries and a backup way to contact people if the radio goes bad. If you miss a check in, people can take action to reestablish contact. One good practice is to report in at specific times or at regular intervals.

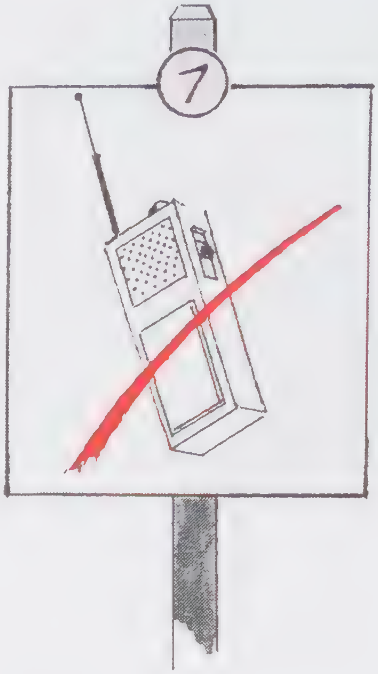


Figure 6.24 If you cannot contact your people or supervisor, you are violating this Watch Out.

Since radios are not normally provided to each individual firefighter, the fire officer should stay within voice contact with each firefighter, or establish a voice relay system where people pass the word down the fireline. Hand signals may be helpful as long as you can count on having someone who will see them. As situations become more dangerous, the communications links MUST become shorter and more reliable.

Anchoring your line is not a sailor's term.

8. **You are constructing fireline without a safe anchor point**. - You may or may not be able to get away with constructing fireline without a good anchor. The risk is that the fire will move around your line and catch you by surprise (Figure 6.25). If you know you don't have a good anchor point, you should assign a lookout to keep an eye on the fire. You definitely need to identify how you will escape if the fire moves around your line. Or, better yet, you may want to start your line construction in a different location.

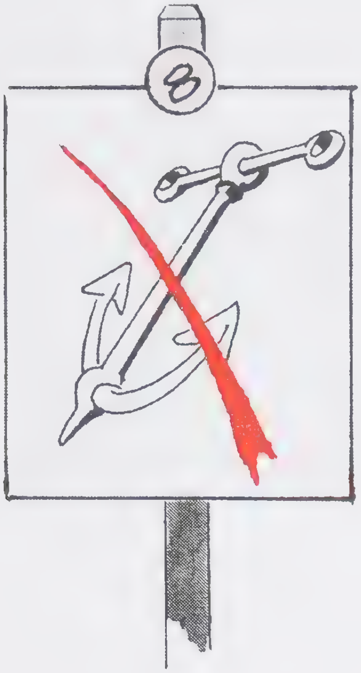


Figure 6.25 You have started your attack without anchoring your line.

9. **You are building fireline downhill and there is fire below you**. - This is not only dangerous, but extremely foolish! There are special rules for downhill line construction, but they don't allow for a case where the fire is below you. If the fire is actually below you, or you expect it will be below you before the line is constructed, back off and select another tactic (Figure 6.26).

The fire holds all the cards if it is below you.

The wind may be at your back as you are working on the ridge, but can you expect it to continue as you move down the hill? All of the cards are stacked against you when you are working downhill with fire below you. Fire has the advantage on a hillside. It moves its quickest when traveling uphill, while the firefighter is moving his or her slowest.

If you need to construct fireline downhill, follow the rules established for this situation, or change the plan and move. These rules are discussed later in this chapter.

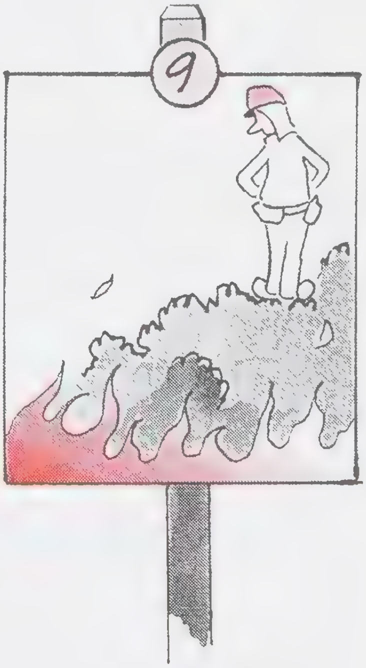


Figure 6.26 You look below you and see a glow, but you continue to cut fireline toward it.

10. **You are attempting a frontal attack on the fire**. - If a fire has developed a distinct head, is it a place you want to be? What special conditions dictate this attack strategy? Are the potential

Move to the flank if the head is too hot to attack.

An indirect attack can be dangerous.

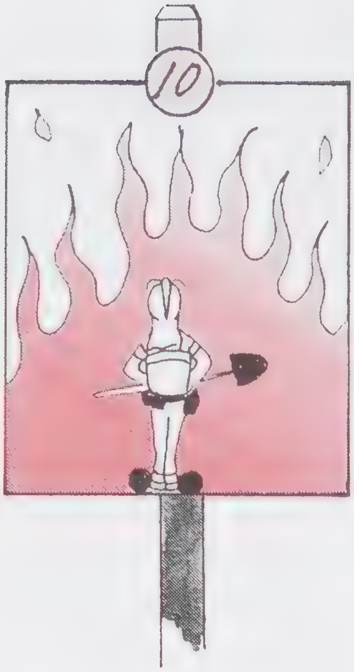


Figure 6.27 You are attacking the head of the fire. You can't understand why you now have two heads to the fire.

benefits worth the risks? Do you have the necessary resources to complete the action? If the answer any of two these questions is "no," or "I don't know," you should modify your plan (Figure 6.27).

If there are special conditions that dictate this type of attack, be sure to post lookouts so you can be made aware of any changing conditions Then anchor your line and go for it. However, be aware that you run the risk of being cut off or of splitting the head, thereby complicating the attack.

If there are no special conditions that dictate such an attack, move to the flank, anchor your line, and move to pinch off the head.

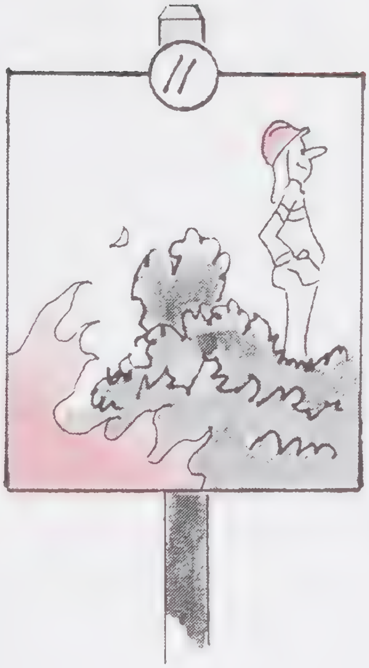


Figure 6.28 You are out in the middle of a brush field, and there is fire all around you. What is wrong with this picture?

11. **There is unburned fuel between you and the fire**. - In this situation you need to either see the fire, or have a lookout who can see it and warn you of changing conditions. This is not a good position to be in if the fire is moving in your direction, especially if your position cannot be easily defended. Have your escape routes and safety zones well thought out (Figure 6.28).

12. **You cannot see the main fire, and you are not in contact with anyone who can**. - You must have information on what the fire is doing, or be in contact with someone who does. If you can't establish a communications link with someone who can see the fire, assign a lookout, or back off, and modify your attack plan (Figure 6.29).

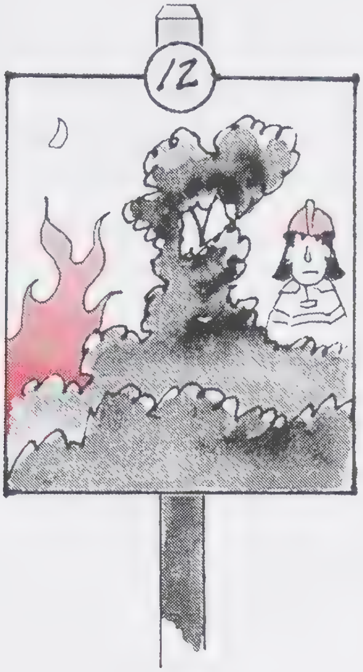


Figure 6.29 You can see the smoke, but that is all. You have no idea what is happening.

13. **You are on a hillside where rolling material can ignite fuel below you.** - Two hazards exist. One is the possibility of fire getting below you. The other is that rolling material from above may actually hit you or your crew, or may dislodge larger material (rocks or logs) that may hit you. You should post lookouts who can warn you and your crew of any threat. Construct the line to keep rolling material from crossing it. If you can't do that, move the line to a location that is more favorable and safer (Figure 6.30).

Don't construct mid-slope fireline unless you have to.

14. **You notice the weather is getting hotter and drier.** This is a good indication that the fire behavior is about to change. Does your plan of attack accommodate an increase in fire behavior? At what point will you pull back to safety?

If it is getting hotter, fire behavior will be changing.

If you take weather readings at regular intervals on the fireline, you can usually detect a change before you can actually feel it (Figure 6.31). Have in your plan a point at which you will pull back. It may be when the relative humidity reaches a certain level, or it may be dictated by the time of day, and the aspect of the topography.

If the wind is changing, beware!

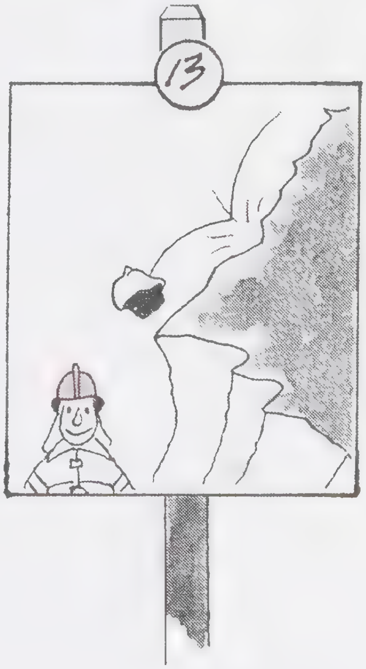


Figure 6.30 Burning material is rolling down the hill, starting fire below you.

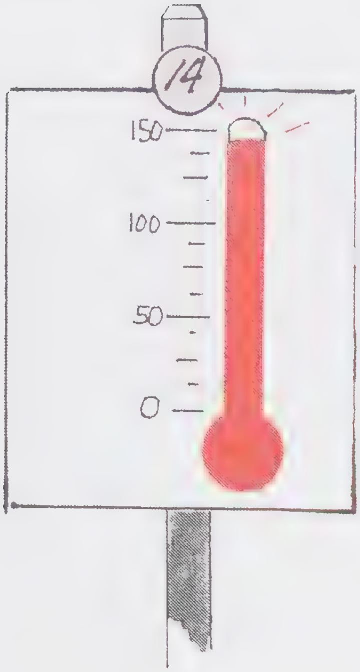


Figure 6.31 It has just turned hot, and the fire is beginning to pick up and burn more intensely.

15. **You feel an increase in the wind or a change in direction**. - This is also a good indication that the fire behavior is about to change. Sometimes, when the wind begins to change, it can do so very quickly. Prepare to move out of the area if this change may impact your section of line. Be especially cautious if this event was not predicted (Figure 6.32).

16. **You are getting frequent spot fires across the fireline**. - This too is an indication that the fire behavior is changing. If this is happening early in the burning period, you may be in for a long day. If you can't handle the number of spots you are getting, and additional forces are not available, the line is lost; it is time to retreat to safety and implement "Plan B" (Figure 6.33).

17. **You notice that the terrain and fuels will make escape to a safety zone difficult**. - If the escape route will not allow you and your crew to move to safety within adequate time parameters, either improve the escape routes, or consider other tactics that will allow you and your crew to be in a safer location. Remember, the longer you and your crew are on the fireline the

If you have more spot fires than you can put out, back off, you have lost the line.

An escape route must be easy to traverse. If it isn't you are violating a Fire Order.

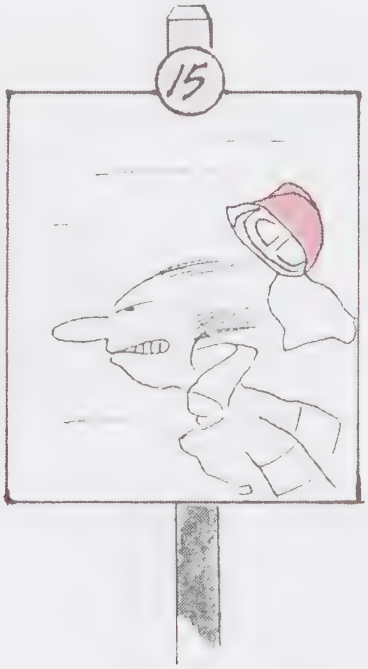


Figure 6.32 The wind just switched directions and increased speed.

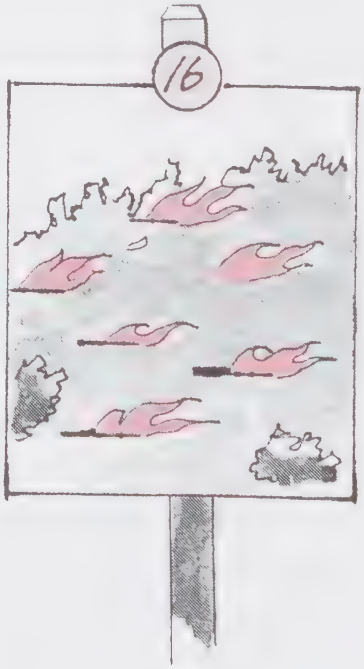


Figure 6.33 There are spot fires all over the place.

more tired you are, thus the longer it will take you to move out (Figure 6.34).

18. **You notice firefighters are napping on the fireline.** - It is not uncommon that when things begin to slow down, tired firefighters will begin to "grab a nap" when they can. You don't want to nap in the green where fire may catch you, or on a dozer line where the tractor may return. There have been cases where fires have caught firefighters while they were napping, or where they were injured by equipment moving along the fireline (Figure 6.35).

If your crew is fatigued and needs to rest, and the situation allows for it, post lookouts and sleep them in groups in a safe location.

These 18 situations that shout "Watch Out!" were developed over the years as accidents happened. Items were added to the list as investigation reports identified dangerous conditions. Several of these "Watch Outs!" are incorporated into the 10 standard Firefighting Orders. However, there are actually more than 18 situations that should get your attention.

The key is that you understand fire and what influences

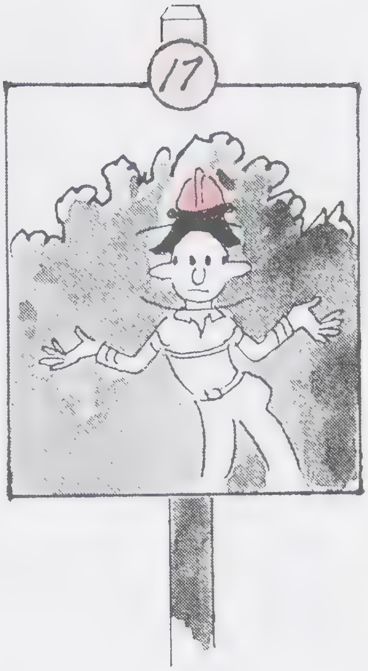


Figure 6.34 You are concerned that you will not be able to reach the safety zone.

Be sure to nap in a safe location; post lookouts to warn of potential danger.

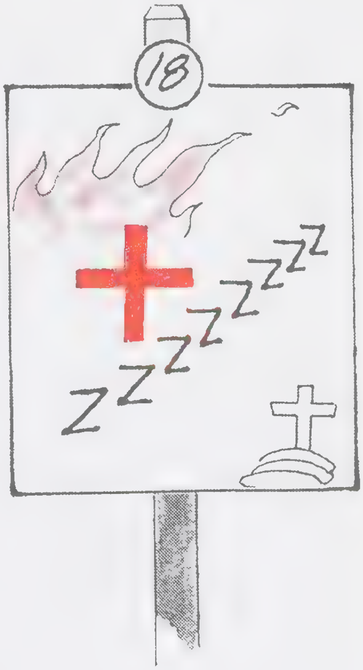


Figure 6.35 You are tired and want to get some sleep.

The 18 situations that shout "Watch Out!" were developed as a result of firefighters being injured or killed.

changes in it. Then you develop a means to track changes in these influences. Some of the things that you can do to keep the surprises to a minimum are:

- Take weather readings regularly.
- Maintain communications with those around you.
- Monitor the fire behavior and note any changes.
- Have contingency plans; know what you will do if certain events happen.
- Time tag your tactics; set a time when a specific tactic will become inappropriate.
- Think "globally," beyond the section of line you are working on. Know what is happening elsewhere and why!

Have contingency plans!

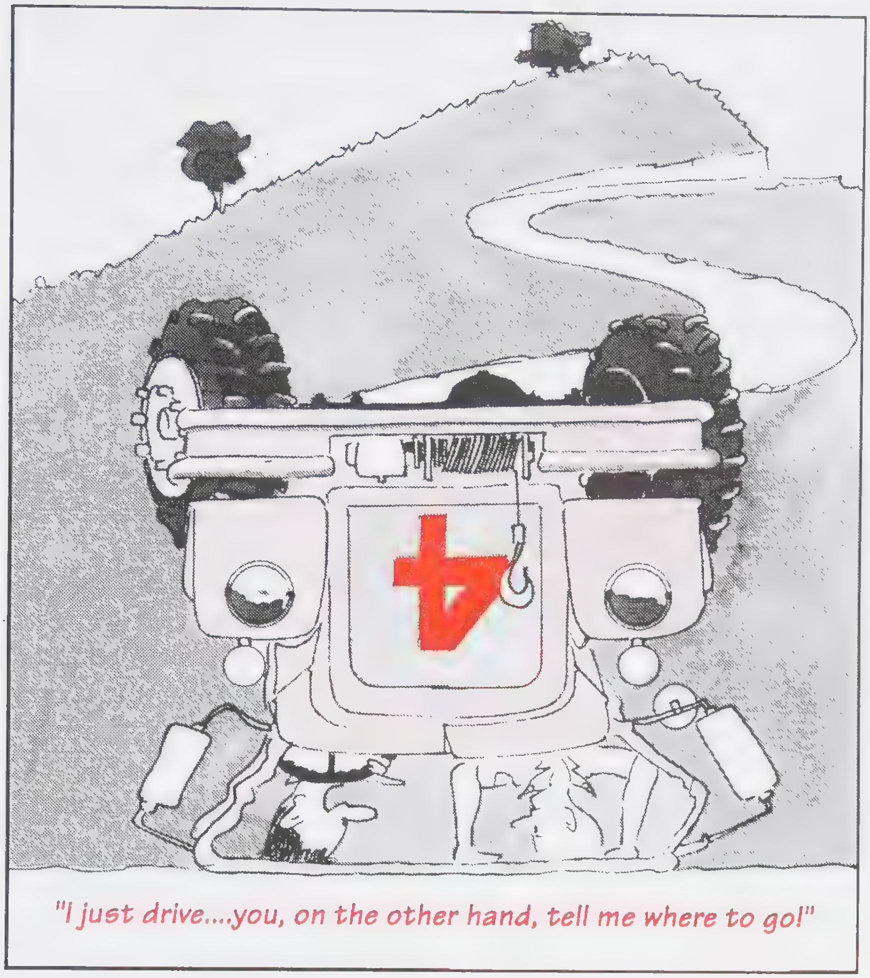
Fire Situations that Kill

There are five general causal factors that kill or injure wildland firefighters. Dangerous situations are easier to spot if you are not in them. As a fire officer you should be aware of these situations and be in a position to prevent them from happening, if possible. They are traffic accidents, burns, falling objects, heart attacks, and aircraft accidents.

Traffic accidents - Each year firefighters are killed in traffic accidents while responding to an incident, while on an incident, or when returning to quarters. All traffic accidents are preventable. The most important thing you and your personnel can do is to drive defensively at all times. While en route to an incident, when the adrenaline is running high and you are in a hurry, never forget that your mission is to get to the scene to render aid. Getting in an accident will prevent you from doing that. In fact, you may yourself become an emergency that someone else will have to deal with (Figure 6.36).

The fire is not the only danger to the firefighter.

The red lights and siren give you license to move a little quicker than the average driver, but they don't give you license to put others in jeopardy. You are not "Moses, parting the Red Sea," so don't drive like it. Realize that when you are excited, your focus narrows, and you may not see the cars you would normally see with your peripheral vision. Compensate by driving with a purpose and with calculated caution. Give other drivers time to hear the siren, see the red lights, and get out of your way. If you



"I just drive....you, on the other hand, tell me where to go!"

Figure 6.36 The engine never made it to the fire; you were in an accident. The engineer is explaining to the fire officer, "I'll drive...you on the other hand, tell me where to go!"

If you don't get to a fire because you were in an accident, you can't fight much fire!

drive in an alert, but relaxed mode, you will be much more prepared to deal with the incident when you arrive.

Burns received during a burnover - Hundreds of firefighters have died while fighting wildland fires; thousands have been involved in "near-miss" situations. There are fires with names like Griffith Park, Rattlesnake, Blackwater, Dude, Loop, Mann Gulch, and South Canyon which have killed several people each. But, the majority of the firefighters have died alone (Figure 6.37). Research shows there are five common denominators to fatal or near-fatal accidents. They are (Figure 6.38):

There are five common denominators to fires where firefighters have been killed.

- Most incidents happen on smaller fires or on isolated sectors of larger fires. You'd think that most accidents on a wildland fire occur when a fire is "hauling" and overruns crews as they are fighting fire. Not true!

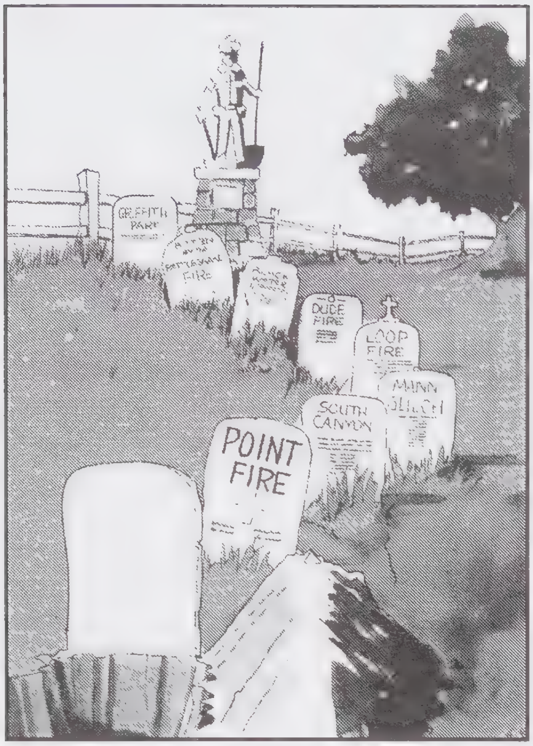


Figure 6.37 There are many reminders of fires that have turned deadly. Let's learn from them and not forget that firefighting is a dangerous profession.

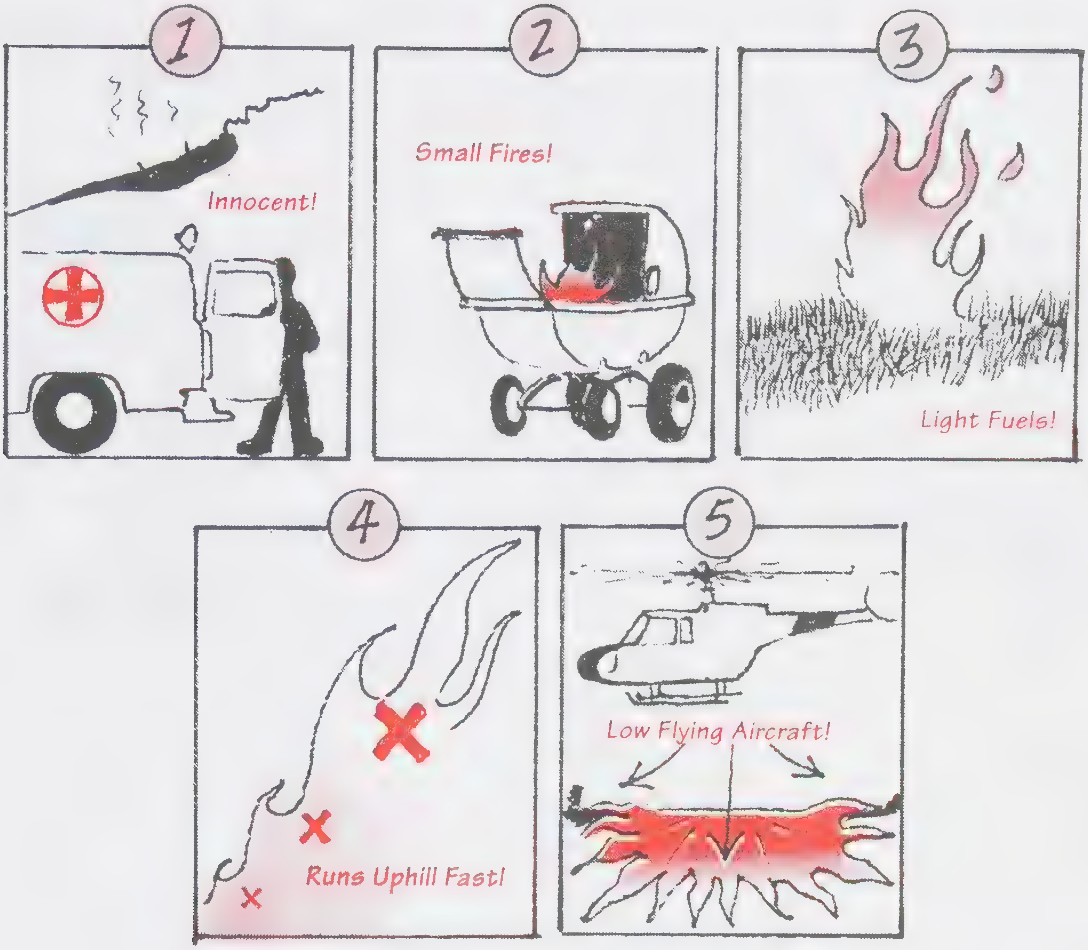
- Most fires are innocent in appearance before the "flare-up" or "blowup." In some cases, tragedies occur in the mop-up stage. Research shows that firefighters are caught by small, unanticipated events like a quick change in wind speed or direction. The lesson to be learned is never let down your guard—be prepared for any eventuality.
- Flare-ups generally occur in deceptively light fuels. Light fuels are more responsive to changes in atmospheric conditions, easier to ignite, and can burn with extreme speed, when being pushed by a wind or when located on a slope.
- Fires run uphill surprisingly fast in chimneys, gullies, and on steep slopes. These topographic features support rapid rates-of-spread.
- Some suppression tools, such as helicopters or airtankers, can adversely affect fire behavior. The blasts of air from low-flying aircraft have been known to cause flare-ups. The vortices from wing-tips or rotor blades can push burning material across firelines or fan fuels into a flare-up.

Most of these factors tie back to events that cause fire behavior to change very quickly. Don't ever underestimate how fast a situation can go bad. Unexpected winds, or extreme and erratic fire behavior may be involved. In extreme cases, you may not see or hear any warning signals. Under such conditions, the obvious signs of a change, such as smoke and the noise of the fire, are noticeable only after the situation has become critical.

Know the warning signs for dangerous situations.

Falling objects - Falling snags, "widow makers," and rolling rocks and logs have all killed firefighters. Snags or other falling things are the second highest factor in the death or injury of firefighters on the fireline. There is an old saying, "When a tree falls and no one sees it, does it make a sound?" NO! In this case, snags fall with little or no sound. If you are fighting fire in fuels with a number of burning dead trees, consider them a hazard like downed powerlines, or other hazardous situations. Flag them! Watch them! Stay away from them! "Widow makers" are particularly a problem when the wind is blowing, so if you don't have to be in the woods when the wind is blowing, stay out (Figure 6.39).

Things don't fall UP!


1
Innocent!
2
Small Fires!
3
Light Fuels!
4
Runs Uphill Fast!
5
Low Flying Aircraft!

Rocks and logs are often dislodged by ground fire. So if you are working mid-slope, and the area contains rocks or logs, be very careful. If you can, turn the logs so that they are perpendicular to the slope, or post lookouts who can warn you when something starts to roll. Have a plan covering which way to run.

Heart attack - Maintaining physical fitness, eating properly, and having regular checkups are the key to not having a heart attack on the fireline. Don't wait until you have a problem to develop a preventive maintenance plan for your body. Many firefighters have better preventative maintenance plans for their engines than they have for themselves (Figure 6.40).

Most firefighters take better care of their engines than of themselves.

Aircraft accidents - The number of aircraft used during a wildland fire grows each year. You, as a fire officer, cannot directly affect the safety of air operations. You can ensure, however, that if you see a hazard like powerlines, tall snags, or towers, that

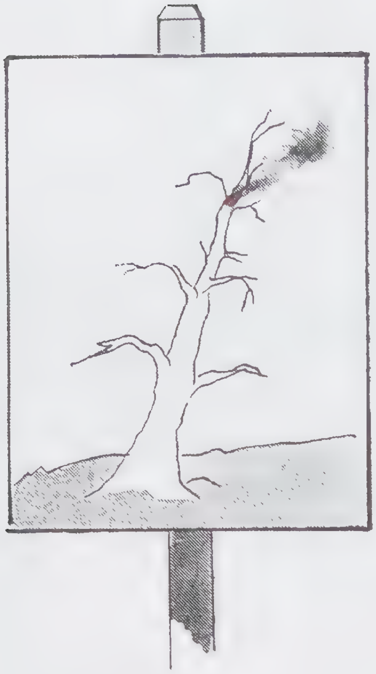


Figure 6.39 Snags or falling objects are the second leading killer of wildland firefighters. "When a tree falls and no one sees it, does it make a sound"? In the case of snags, they usually do not make any sound.

You will rarely hear the snag before it hits you.

you get that information to the air attack officer or pilot (Figure 6.41).

Fire Shelters

Figure 6.40 If you are overweight and out of shape, you shouldn't be on the fireline.

Fire shelters have saved hundreds of lives! You must ensure that you and your crew know when and how to deploy them. Fire shelters have two primary functions: to provide cooler, breathable air to protect your lungs and airway; and to reflect radiated heat energy for short periods. Fire shelters are made of a thin aluminum-glass laminated material that is designed to reflect 95 percent of radiated heat, and to withstand limited convective heat or direct flame impingement (Figure 6.42). Fire shelters are to be carried by all personnel assigned to fireline duty. However, they are not "bunkers," nor are they meant to be a substitute for common sense or adequate safety zones. Having a fire shelter is not a justification for violating Fire Orders.

Training in the deployment of your fire shelter is mandatory. This training should include hands-on exercises. When conducting this training, do so under realistic conditions, in full protective clothing, wearing gloves and helmet, and in a wind, (even if you have to create a wind using a large fan). Never train with real fire. That is much too dangerous. Practice with old fire shelters or the cheaper, reusable training shelters.

There has been some discussion about where you should seek shelter from a fire: in the cab of a vehicle or in a fire shelter. The concern is that if you take refuge in the cab of your vehicle and then are forced to abandon it, it may not be the best time to enter the raw fire environment. There are cases where firefighters have taken shelter in their engines, and have been driven out by

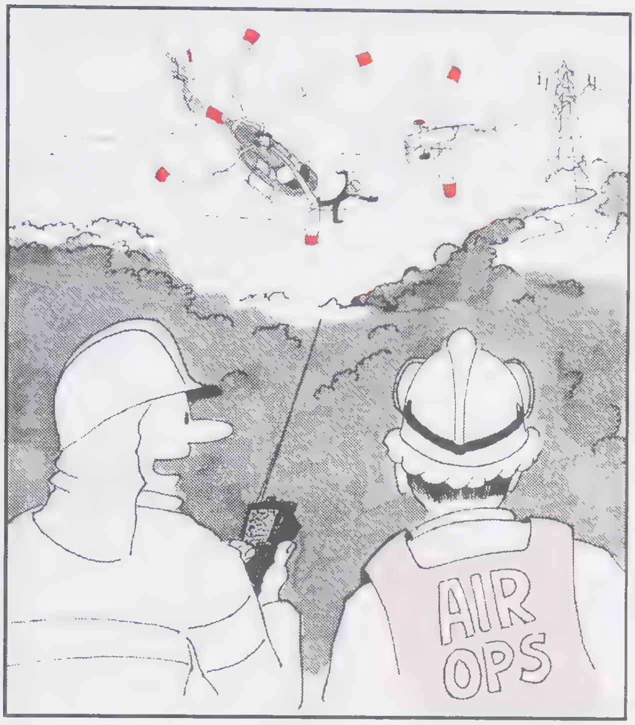


Figure 6.41 This fire officer saw the wires, but didn't warn the air attack officer.

toxic smoke from heated synthetic materials in the cab or from the fire itself, when windows have been shattered and blown out. If you have to seek shelter from a fire, and can deploy your shelter properly, seek refuge in the shelter. If the cab of the vehicle is all you have, stay in it. If you have a shelter but do not have time to deploy it properly, use it to provide protection from radiant heat. Open it and place it near the windows.

As with all firefighting tools, there are "do's" and "don'ts" to proper shelter use. The "do's" of fire shelter use are:

- Train annually on the proper deployment of your fire shelter. Train under windy conditions, if possible. Train to the point that you can properly deploy your shelter in under 25 seconds. The instructions provided with each shelter are not intended to be read on the fireground. You will not have time!
- Carry the shelter on your hip when on the fireline. The carrying pouch is not a place for your rain gear or favorite snacks.
- Use the fire shelter when other escape procedures fail. It is a "last ditch" survival tool. Once you decide that escape is not possible, deploy the shelter quickly.
- Inspect the shelter every couple of weeks during the fire season. Replace it if it shows excessive wear or damage.
- Deploy the shelter in a site free of flammable material (minimum of 4 by 8 foot spot cleared to mineral soil) in the

Fire shelters are meant as a last resort, not as an excuse for breaking the rules.

Once you decide that escape is not possible, deploy your shelter quickly.

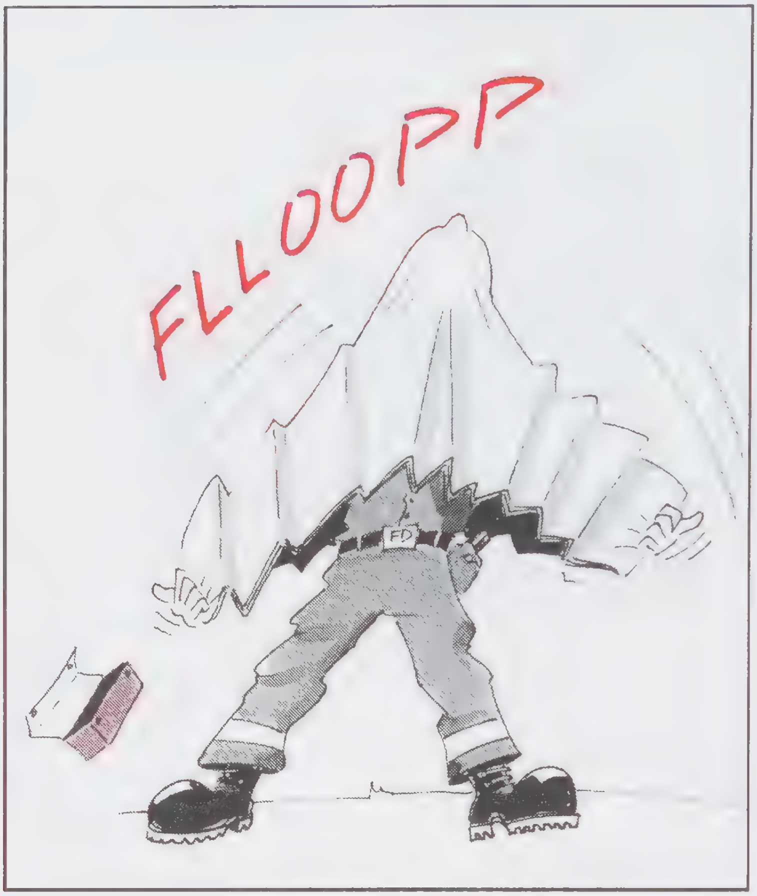


Figure 6.42 Fire shelters are a last-step survival tool. They are made to reflect 95% of radiated heat energy and to provide protection of your airway and lungs. They are not bunkers.

deployment site, wide bulldozer line, previously burned area, or any site that is cleared of fuels. Avoid areas where the fuels are heavy (near logs or heavy brush), or near piles of personal gear or equipment, that may burn for long periods of time.

- Deploy the shelter rather than attempt to "stick it out" in the cab of your engine. If you are in a position that you may be driven from the cab of a vehicle, the chance of being burned during the transition from the cab to the shelter is very high. Keep the vehicle between you and the fire, whenever possible.
- Wear your full personal protective gear. Take drinking water into the shelter if you can.
- Get in your shelter and stay there until the danger has passed. If you must move for any reason, use the shelter as a shield.

Don't plan to use the shelter in lieu of retreating to safety.

- Keep your face "buried" in the soil, breathing the coolest air available. You can survive burns—you will probably not survive severely heat-damaged lungs.

The "don'ts" of fire shelter use are:

- Don't wait until you need to deploy the shelter to read the instructions.
- Don't plan to use the shelter in lieu of retreating to a safety zone. The shelter should be considered a last-resort measure.
- Don't carry the shelter in your field pack, or leave it on the engine.
- Don't deploy the shelter near heavy fuels, or in draws or chimneys that will funnel smoke, hot air or gases, and flames.
- Don't take your field pack inside the shelter with you. Consider it as being lost. Get as far from it as you can.
- Don't wet your clothing or anything you might put over your mouth and nose for respiratory protection. Moist air or clothing will increase the likelihood of internal and external burns.
- Don't plan on doubling up with your partner unless it's an extreme emergency.
- Don't panic if there are pinholes or tears in your shelter. Remember, even with a large tear, you are better off inside the shelter than outside with no protection.

If you have to use indirect fireline, know the risks and take appropriate safety measures.

Downhill or Indirect Fireline Construction

There will be times when the only practical way to attack a fire is from above (or with indirect fireline construction). This can be especially dangerous if the fire is active. The following special guidelines have been developed to aid you in conducting this task as safely as possible:

- **The decision is made by a competent firefighter after thorough scouting**. The decision to drop off a hill toward a fire is not one that should be made without considerable thought. The person who makes the decision has to be experienced, and must know what he or she is doing. In addition, the decision should only be made when the situation has been fully scouted and understood. Without proper scouting, you cannot accurately determine the best location for the fireline and anchor points.

If the fire is below you, move off to one side or relocate the proposed line.

- **Downhill line construction should not be attempted when fire is present directly below the proposed starting point**. Don't attempt a head-on attack—you will lose. Allow the fire to run up to the top of the ridge. Work down the side of the fire, constructing what will become a flank. If there is a cross-slope wind, work on the upwind side.

Post lookouts if you can't see the fire.

- **The fireline should not be in or adjacent to a chimney or chute that could burn out while a crew is in the vicinity**. Attempt to work from spur ridges or on wide slopes. Stay away from areas that tend to funnel or focus fire. You don't want fire to get directly below you. If the fire makes a run, be sure it runs by you, not at you.
- **Establish Communications between the crew working downhill and the crews working toward them from below**. This communications link is critical to ensuring that if the situation begins to change, everyone is aware of it.

Anchor the fireline at the top of the ridge.

- **Post a lookout(s) so that the full length of the fireline is under constant review**. The full fireline must be under constant scrutiny so that if the conditions begin to deteriorate, adequate warning can be given.
- **Ensure that crews will be able to rapidly reach a safety zone from any point along the fireline**. You must have a place to quickly retreat to. The safety zone must be a place you can get to in just minutes. If you can bring fire with you by burning out as you construct the line, your safety zone may be the "black."
- **Anchor the fireline at the top of the ridge**. You don't want the fire you are bringing with you to hook around and cause you problems. You should always anchor your fireline.
- **Avoid underslung fireline construction if you can**. Underslung or undercut line is always a problem. It is hard to construct and hold. Work up and down, keeping the fireline as short as possible.
- **Bring fire with you as you construct the line from the ridge**. As noted above, the burned area may serve as an alternate safety zone if necessary.

Lookouts
Awareness
Communications
Escape routes
Safety zones.

LACES

The acronym LCES was developed by Paul Gleason, a highly experienced and respected fire specialist employed by the USDA, Forest Service. He was concerned that trying to remember the 10 Fire Orders, 18 "Watch Out!" situations, five common denominators to fatal fires, etc., overloads the firefighter. His goal was to provide a simple way to help firefighters remember some key elements to survival. LCES stands for *lookouts, communications, escape routes, and safety zones.* An "A" has been added to LCES for awareness, because unless you are aware, all else may fail (Figure 6.43). Think about these key safety elements *every time you tie your boot LACES!*

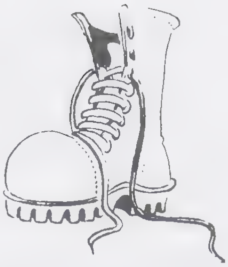


Figure 6.43 LACES identifies key steps to improve your chance of survival if the unexpected happens.

If you aren't aware of the situation, you can't initiate necessary actions.

Lookouts - The lookout is the eyes of the crew and its leader. Lookouts should be in a position from which they can see the fireline, the fire itself, and the crews that are working the line. They should be able to recognize and anticipate dangerous situations, and must report changes immediately.

Awareness - Lookouts should watch for changes in the fire's location and behavior. They should know the plan, so that they can relate it to what they see the crews accomplishing and what the fire is doing. Lookouts should also track the weather by taking readings at regular intervals. They should watch the sky for telltale signs of change. Finally, fire officers/crew leaders must be able to understand what the lookouts are trying to tell them, or posting lookouts will serve no purpose. Remember, however, that awareness is the responsibility of everyone on the fire.

The length of your escape routes should be measured in minutes or seconds.

Communications - The fire officer, crew leaders, and lookout(s) should have a quick, reliable, and tested way to communicate with others. This may be by direct radio contact, or through a lookout or other relay point. If you plan on using the radio system, have an alternative way to communicate in case the radios fail for any reason. Establish regular reporting times. The communications link down to the individual firefighter may be by word of mouth. It can be very noisy on the fireline, so as the noise gets louder, the distance between individual firefighters will have to be shortened to ensure adequate communication.

Escape Routes - Note that routes is plural. Have two planned routes of escape. If your primary route is cut off, know what you are going to do. Every person on the fireline must know the plan. They have to know what you, the fire officer, are going to do, and what is

The elements of LACES are all interconnected and interdependent.

expected of them. Everyone must also know what is to trigger a move to the safety zone. It is important to remember that, as the crews tire, they will not be able to retreat as quickly. You may have to shorten the distance between the work site and the safety zone, or provide an escape route that is "faster." Escape routes should not be measured in feet or chains, but in minutes and seconds. Make a conservative estimate of the time you will need to get the crew to safety. Use that as the guide as to how many seconds of escape route you can tolerate. If you are constructing an indirect line, the establishment of two escape routes may be a challenge.

Safety Zones - Safety zones are places of refuge, places you can be assured of your safety. Their size is dictated by the fuel, terrain, weather conditions, and worst-case fire behavior. The use of fire shelters should not be necessary; however, that isn't to say you can't use them.

LACES tries to provide for a "safety net" if something goes wrong. It focuses on the important elements of the Fire Orders. The elements of LACES should be as commonplace in the firefighter's vocabulary as fire shelter, helmet, gloves, water, and shovel. The elements of LACES are interconnected and interdependent, like a chain. The LACES chain is only as strong as its weakest link.

You must balance the risks of fire protection with the overall need to contain the fire.

Wildland/Urban Interface Hazards

When there are structures being threatened by a wildland fire, the rules change. The "attitude" of the fire fight is different when life and property are added to the equation. In some instances, greater risks are taken. The reality is that firefighters are expected to protect and save structures. Understandably, the number of structures is considered more newsworthy than the acres burned. The general public and the news media can't relate to the size of an acre, but everyone can relate to the loss of a house or home.

The challenge for the fire officer is to balance the risks of structure protection with an overall need for containment of the wildland fire. The fact that structures are threatened narrows the focus of your actions. Realizing this, how do you balance safety, the pressures to protect life and property, and the need to construct fireline?

Pressures of Evacuation - Do you or don't you evacuate? First of all, ordering an evacuation may not be within the scope of your authority (Figure 6.44). This usually falls in the jurisdiction of law enforcement. But, you, as an "expert" fire officer, may have to recommend evacuation.

Attempting to move people out of an area at the same time that you are trying to move in can be difficult, especially if smoke is present.

Your goal as a fire officer or incident commander is to select a strategy that minimizes the loss of life and property. Each situation will be different. The best case is one where there is time to move people from an area and still have adequate time to set up to protect property. Not having to worry about the safety of civilians, would relieve you of a tremendous burden. But, unfortunately it doesn't happen very often that you have adequate time to completely evacuate an area prior to attacking the fire.

Before you order an evacuation, have a plan.

The Australian Bush Fire Service conducted several studies into the question of evacuations. They concluded that more lives would probably be saved if they did not order evacuations. The basis for their conclusion was that historical data shows that more people are injured during the evacuation process than would be if they

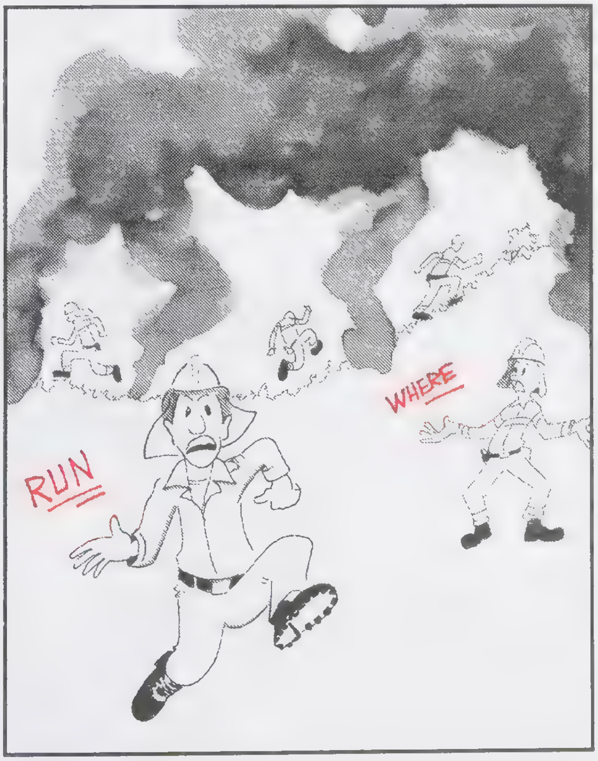


Figure 6.44 Whether to evacuate or not is one of the tougher decisions you will have to make. It not only involves people and their safety, but many people won't want to "abandon" their homes.

Mandatory evacuations are usually within the scope of authority of law enforcement.

had stayed put. The key is being able to distinguish between unnecessary evacuations and those that are truly needed or prudent.

The criteria for when to order an evacuation should be discussed well before a fire starts. The decision should be based on such things as the level of community education and awareness, whether there is adequate defensible space, the condition of the roads, availability of water for firefighting, and the availability of a communications system which can be used to warn the public of impending danger.

There are a number of safety issues involved during an evacuation or structure protection which are discussed in detail in Chapter 10. Following are several of the dangers faced by firefighters in the wildland/urban interface.

Your plan should be to minimize loss of life and property.

Liquid Petroleum Gas Tanks - In many rural areas, liquid petroleum gas (LPG) is used for heating and cooking (Figure 6.45). The pressure-vessels used to store the LPG are usually found next to or near most homes. These tanks and their contents constitute a real problem if they have an accumulation of flammable material around them.

If time allows, remove flammable fuels from around the tanks. If that isn't possible, and there is fire nearby, try to keep the tank

Downed powerlines have killed many firefighters.

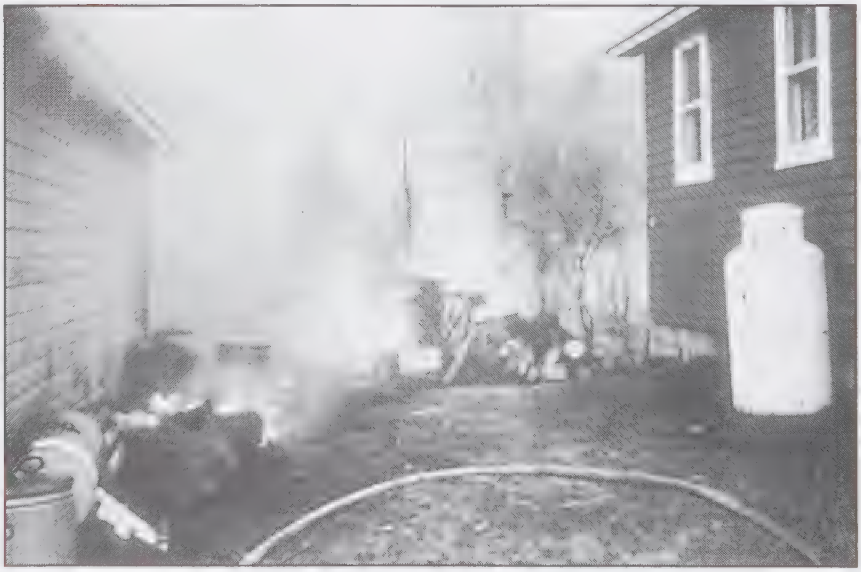


Figure 6.45 LPG tanks constitute a significant hazard, especially if there is a buildup of flammable materials nearby, which could heat the tank to the point where it may vent or rupture.

cool. However, if there is already direct flame impingement on the tank, clear the area immediately—the tank may rupture violently!

Powerlines - We are a society dependent on electricity. Everywhere you go, electrical transmission lines will be present. Consider all powerlines a hazard. Don't park under them. If lines are down, cordon off the area so no one will accidentally stumble into them.

LPG tanks can explode like bombs.

In some cases, when there are many lines down, you may ask the power company to shut down the power grid in an area. However, you may also be shutting down the booster pumps for the water system, rendering the fire hydrants useless. In addition, this may pose a problem for people who can safely remain in their homes, but are on respirators or other life support systems.

Vehicles, chemicals, and other hazardous materials - Almost everyone has some form of hazardous material stored in or near their homes. It may be garden fertilizers; swimming pool chemicals; or fuel for the lawn mower, chainsaw, or farm equipment (Figure 6.46). There may also be a buildup of "yard accumulation" that may include abandoned vehicles, lumber, and other flammable materials. Consider these hazardous; stay upwind, and keep the fire from getting into these items if you can.

Almost every home contains hazardous chemicals.

Wildland firefighters/structural firefighters - Wildland firefighters are trained and equipped to fight wildland fires; structural firefighters are trained and equipped to fight structure fires. Some firefighters are cross-trained to meet the various needs within their jurisdictions. It is a major concern if you try to take firefighters highly trained in one area, and ask them to function in another area for which they are not trained or equipped.

Do not ask people to work beyond their training and experience. Don't ask wildland firefighters to do interior attacks. They normally will not be equipped with turnouts or self-contained breathing apparatus. Don't ask structural firefighters to make a progressive hose lay up and over a ridge on a hot summer day in their turnouts, or ask a wildland firefighter to fight a high-rise fire (Figure 6.47).

Don't ask firefighters to take actions that they are not trained or equipped to handle.

The same is true of the equipment. Don't ask the operator of a $300,000 triple-combination engine to leave the roadbed and

COMMON HOUSEHOLD HAZARDS

Identify all of the hazardous materials and insure that they will not hamper your operations.

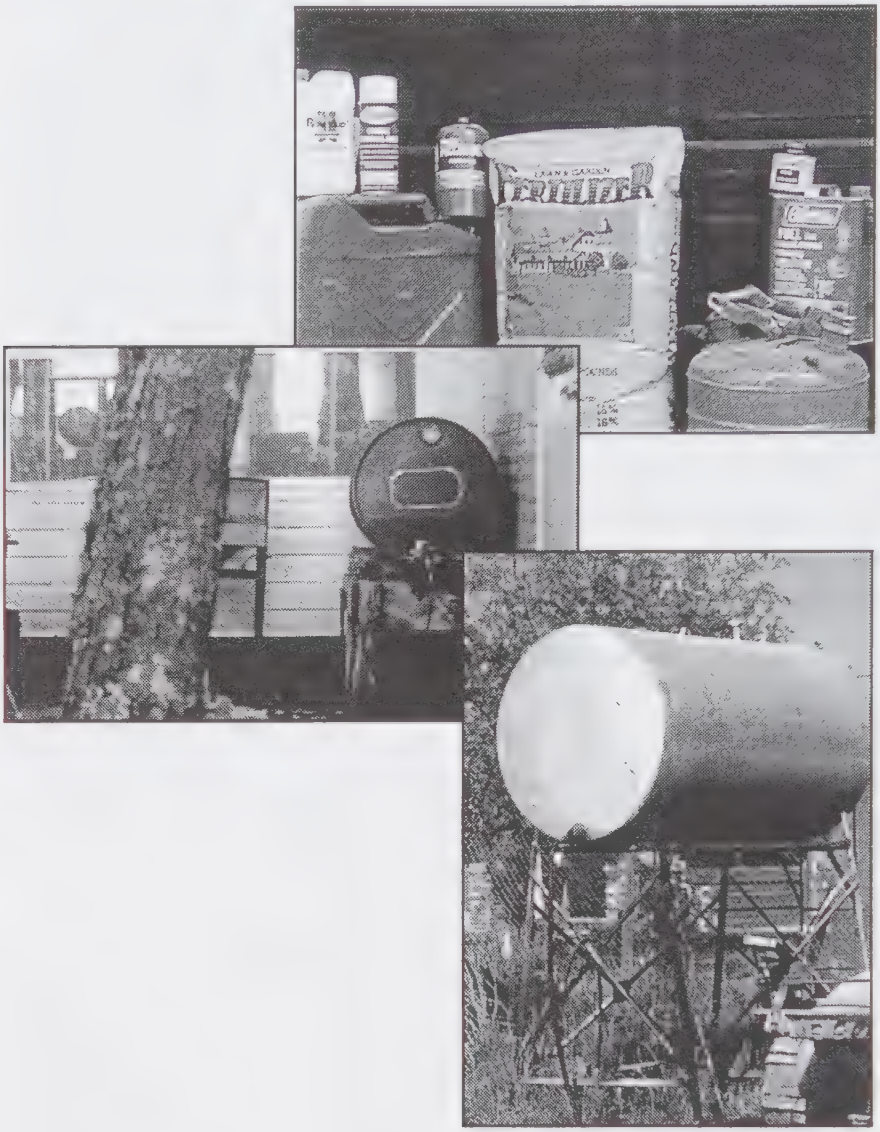


Figure 6.46 There are hazardous materials in or near every structure. But, in rural areas, there are some special ones that could cause you or your people harm.

Match the equipment and personnel to the task.

take off behind the bulldozer (Figure 6.48). **Match the equipment and personnel to the task at hand. To do otherwise would put the firefighters at unnecessary risk.**

Your Role as a Safety Officer

You've undoubtedly heard that every firefighter is responsible for safety. But, you as the fire officer are the first level safety officer. That is your primary responsibility. Operations, logistics, etc., are all a distant second (Figure 6.49).

It is unlikely that we will ever be able to prevent all accidents. Firefighting is dangerous, and that is the way it is. But, the number and/or the seriousness of accidents can be minimized and reduced. That is where you as a fire officer get involved.

The fire officer is the first-level safety officer.

Firefighters normally work as a team, a company, crew, or squad. A newly formed unit generally has a higher rate of accidents than one which has been working together for some time. This means you need to pay special attention early in the fire season, when the unit is still more or less a group of individuals rather than a cohesive team. Teamwork starts with two people, then four, eight, etc. Get your people working together.

Get your people working together as a team.

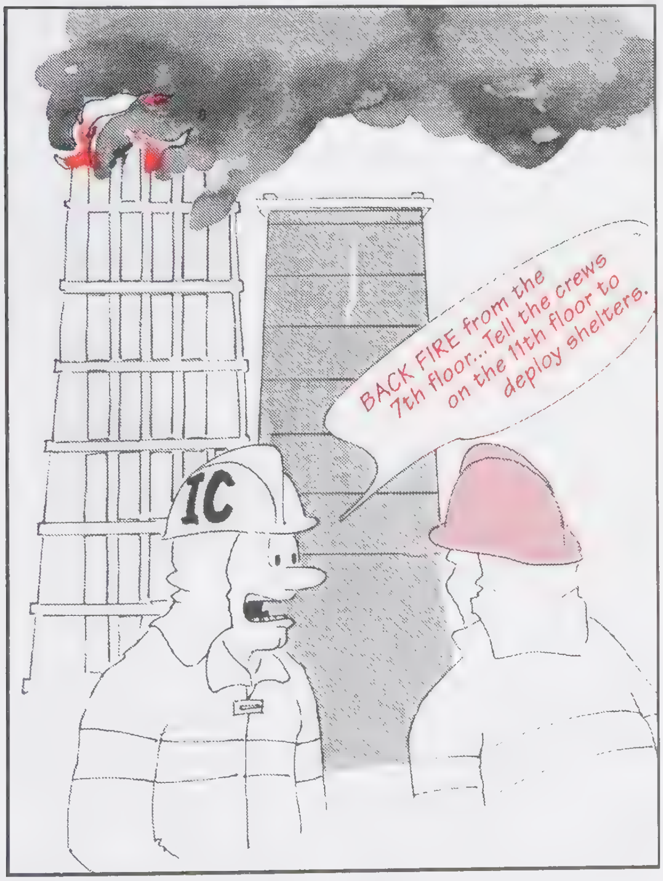

BACK FIRE from the 7th floor...Tell the crews on the 11th floor to deploy shelters.
IC

Figure 6.47 Don't ask firefighters to take on a task for which they are not trained or equipped.

The following is a simple checklist for you to consider in your role as a safety officer:

- Ensure that safety standards are being followed, and that all personnel wear full safety gear.
- Review the task at hand with the firefighters, and discuss

All personnel should wear full safety gear.

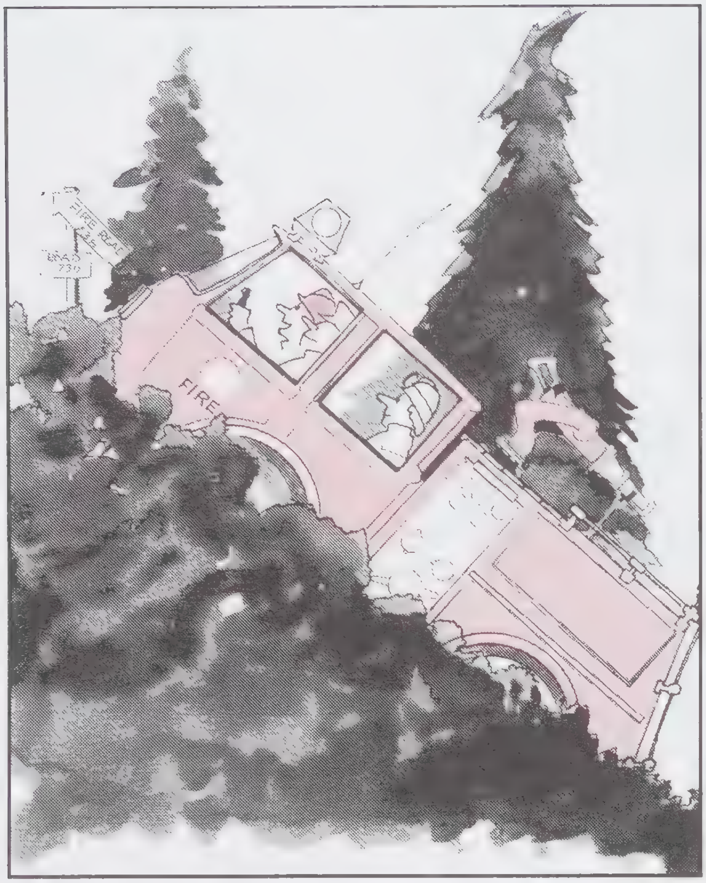


Figure 6.48 Type 1 engines are designed to stay relatively close to the roadway.

contingencies if conditions turn sour.

- Ensure that the personnel assigned to you are qualified to do what they are doing.
- Make sure that the lookout you have posted understands the assignment, and has the training and experience to perform it.
- Review the work of the crew on the line. "Talk up" safety. Make sure that safety is part of the job, not an extra thing that has to be dealt with.
- If an accident does happen, conduct a personal investigation. Show your crew that you care and are interested.
- Constantly check on the progress of the work on the fireline. Take note how each firefighter is performing his or her assignment. Correct any safety deficiencies immediately.

You, as a safety officer, should ask for direction and guidance whenever you are in doubt, or the situation is becoming serious. Ask your line officer, fire management officer, or division/group supervisor what they think of "the plan" and how things are going. They have a responsibility to provide management oversight of you, and to ensure that your plan and actions are safe and proper. One of the primary concerns after the tragedy on the South Canyon fire was that there was limited or no management oversight of the incident. To ensure that that doesn't happen to you on one of your incidents, ask for advice and help if you need it, and keep your supervisors well informed on conditions.

Not all engines are created equal.

Figure 6.49 The primary role of a fire officer is that of a safety officer. Ensure the personnel assigned to you perform their tasks in a safe and effective manner.

As a leader, you set the example. If you carry the hand tool wrong, you give tacit approval for your personnel to also carry their tools incorrectly. If you swear, they can swear. If you don't wear all of your safety gear, they won't wear all of theirs. Lead by example (Figure 6.50). It is not okay to play the old game, "do as I say, not as I do!"

Figure 6.50 This fire officer does not lead by example. His motto is, "do as I say, not as I do!" This is unacceptable.

Lead by example.

In excerpts from a USDA, Forest Service 1993 report on the Butte Fire, Richard Rothermel stated, "On August 29, 1985, 73 firefighters were forced into cleared safety zones while fighting the Butte Fire…only 5 firefighters needed to be hospitalized (with relatively minor problems given the circumstances)…the others were not injured. Investigators estimated that without the protection of the safety zones and the reflective fire shelters…at least 60, if not all the firefighters, would have died."

Develop a passion for safety and a commitment to training.

Investigators noted several other factors that contributed to firefighter survival on this dangerous fire:

- Large safety zones (larger than football fields) that could be reached easily were prepared and identified in advance.
- The crews had survival training.
- Well-trained leaders directed the crews to the safety zones, and directed them to deploy their shelters when it became necessary.
- Well-disciplined crews followed orders even though they were badly frightened.
- Maintaining radio communications helped to provide ongoing instructions and reassurance.

Develop a passion for safety. Some of the things that this entails are: a commitment to training, the willingness to listen respectfully to your people and their concerns, an effort to maintain good morale and a sense of team spirit, the ability to communicate to your people that it is as important to work safely as it is to put the fire out.

Notes:

7

Incident Command System

> ***"With no overall game plan, it is doubtful that the participants will play their proper roles. This role confusion means uncoordinated action, resulting in the breakdown of the strategic, tactical, and task levels of firefighting."*** *Chief Alan Brunacini, Fire Command, NFPA, 1985.*

The Incident Command System (ICS) is an "all-risk" operating system that can be adapted to fit any type and size of incident. The system can expand or contract as the situation changes. Think of ICS as you would a computer operating system, like MS DOS, System 7, or OS/2. A computer operating system and ICS are sets of rules that define relationships between and responsibilities of various parts of a "machine."

Computer operating systems do not "know" a thing about word processing, spread sheets, or data bases. ICS doesn't know a thing about dealing with fires, floods, or earthquakes. It is the people who use ICS who must bring with them the expertise on a particular subject.

Most people are introduced to ICS by being shown a large organization chart (Figure 7.1), and most people's first impression is, "Where am I going to get the people to fill all of those boxes?" **ICS requires only one position to be filled—that of an Incident Commander (IC).** The IC fills all of the boxes (responsibilities) until he or she assigns to someone else responsibility for a particular function. Each box is filled only if and when necessary. The system is very flexible. As noted, it can grow and shrink to meet differing needs. If used properly, it is a very cost-effective and efficient management system.

In this chapter, you'll

- *Learn the basis and design behind the Incident Command System.*
- *Learn how to organize major incidents.*
- *Learn how ICS can assist in incident planning.*
- *Learn the role of the Command Staff.*
- *Learn the role of various ICS positions.*
- *Learn the functions of the various ICS facilities.*
- *Learn how to manage resources.*
- *Appreciate the need to think "divisions."*

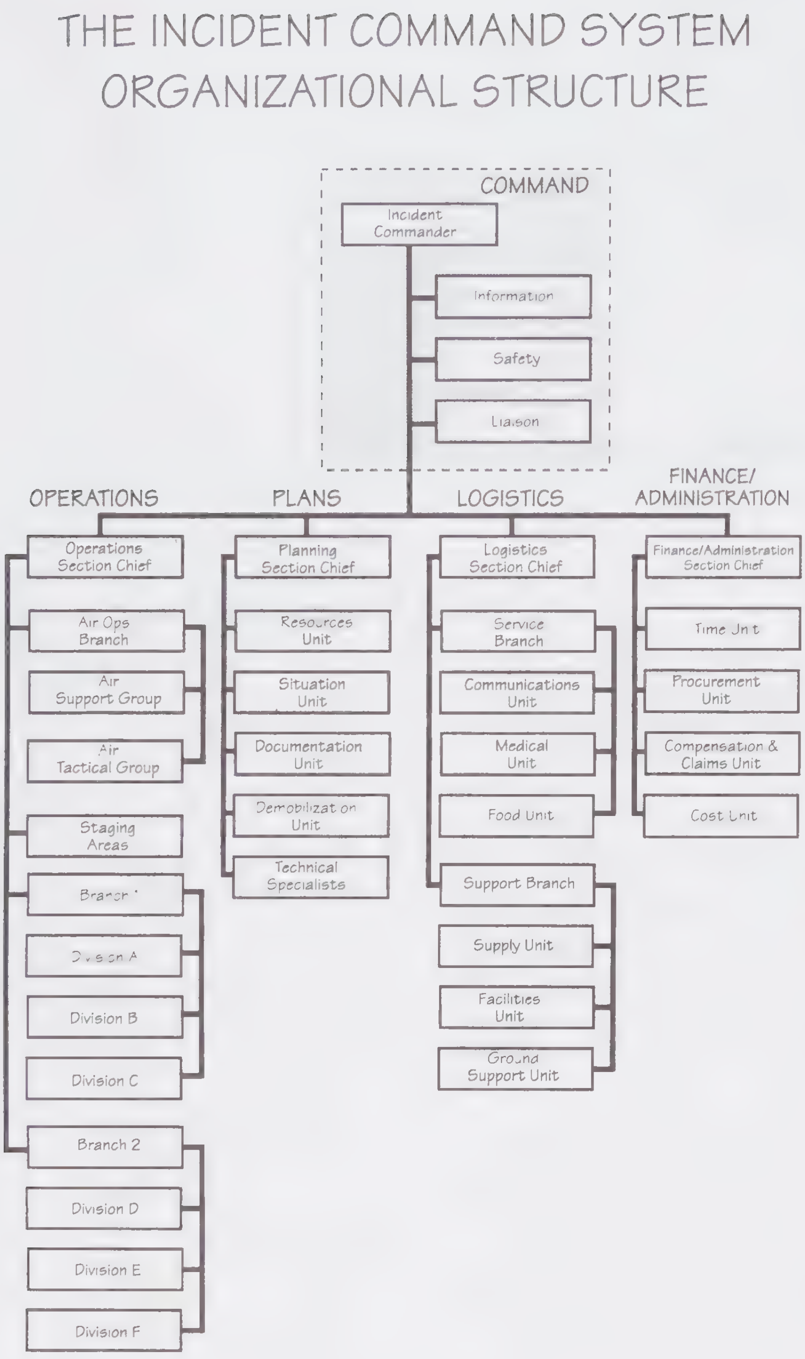

THE INCIDENT COMMAND SYSTEM ORGANIZATIONAL STRUCTURE
COMMAND
Incident Commander
Information
Safety
Liaison
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Air Ops Branch
Air Support Group
Air Tactical Group
Staging Areas
Branch 1
Division A
Division B
Division C
Branch 2
Division D
Division E
Division F
Planning Section Chief
Resources Unit
Situation Unit
Documentation Unit
Demobilization Unit
Technical Specialists
Logistics Section Chief
Service Branch
Communications Unit
Medical Unit
Food Unit
Support Branch
Supply Unit
Facilities Unit
Ground Support Unit
Finance/Administration Section Chief
Time Unit
Procurement Unit
Compensation & Claims Unit
Cost Unit

Figure 7.1 Even though this organization chart has 37 positions listed, ICS only requires one position: the Incident Commander.

When do you start to use ICS? Experience has shown that it is not wise, effective, or efficient to switch operational schemes in the middle of an emergency. Experience has also shown that to make ICS work, it should be used all of the time. Think ICS even at the simplest of events. This doesn't have to mean you order a score of people to fill overhead positions, but you think Incident Commander, Divisions, Staging, Logistics, Operations, Planning, etc. This is actually very simple, and it makes the transition into a major operation so much easier.

Management by Objectives' and Unity of Command

Two key philosophies that were used in the development of the Incident Command System were the need for Management by Objectives and a Unity of Command.

Management by Objectives - It is important that all those assigned to an incident understand what the overall plan is so that they can see how they fit into that plan. ICS requires that simple objectives be developed. These objectives should be attainable, measurable, and flexible.

Attainable - The objectives must be achievable with the resources that can be allocated to the incident, even though it may take several operational periods to accomplish them.

Measurable - The objectives should be written in such a way that it is easy to measure whether or not they were achieved.

Flexible - The objectives should be broad enough to allow for both strategic and tactical changes and modifications as needed.

Above all, the objectives should be based on common sense, in that they are practical and suitable for the situation at hand. **They must be safe to use and cost effective**. As much as possible, they should be politically and environmentally sensitive. You should also develop alternative objectives that you can bring into play if the first ones become outdated.

Don't forget that agency policy will affect the objectives and strategies. The best example of this is the use of bulldozers in National Parks and Wilderness Areas. The use of bulldozers in these areas is often prohibited, so don't base your whole plan on using them. Always remember who you are working for when you develop your objectives.

Unity of Command - This term has several meanings within the Incident Command System. It means that every individual in the organization has a designated supervisor and that there is linking between all individuals on the incident. It also means that there is one command focus. The command structure might include several people, but they speak with one voice and with one set of objectives.

Unity of Command also means there is a simple way of transferring command from one person to another. This may happen when a more qualified person arrives on scene, the fire moves from one jurisdiction to another, or there is a rotation of people because of the long duration of an event.

Without a functioning organization, your firefighting efforts will be ineffective.

Write down your overall objectives for fighting the fire.

ICS only requires the filling of one position-the Incident Commander.

The ICS Organizational Scheme

The organization of the Incident Command System is built around five major management activities (Figure 7.2). They are:

- **Command** - Sets the objectives and priorities and has overall responsibility for the management of the incident.
- **Operations** - Conducts tactical operations to carry out the plan. Operations establishes the tactical objectives, develops the organization, and directs all resources.

All agencies with responsibility on a fire should be represented at the command level.

The five elements of ICS are: Command, Operations, Planning, Logistics, and Finance and Administration.

- **Planning** - Develops the action plan to accomplish the objectives. Plans also collects and evaluates information and maintains resource status.
- **Logistics** - Provides support to meet the needs of the incident. They provide the resources and all services needed during the incident.
- **Finance/Administration** - Monitors costs related to the incident and provides accounting, procurement, time recording, and cost analysis.

INCIDENT COMMAND SYSTEM MAJOR ACTIVITIES

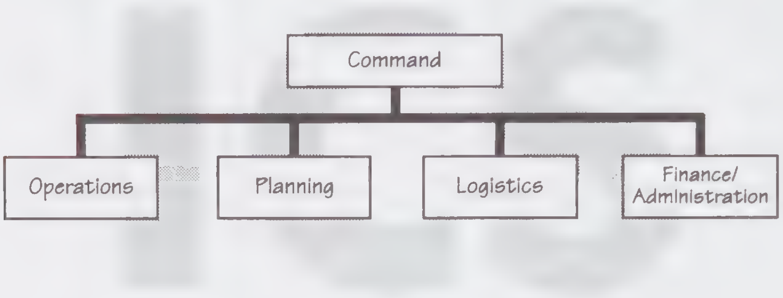


Figure 7.2 There are five major management activities within the Incident Command System.

For ICS to function properly, it should be used all the time. This avoids changing organizational schemes if the incident becomes a major event.

On a small incident, these functions may be filled by the Incident Commander. As the incident grows in complexity, the ICS organization should grow with it. As you can see in Figure 7.1, each of the primary organization sections has sub-elements.

Until a sub-element position is filled, the person higher up on the organization chart is responsible for that function. In Figure 7.3, you can see that the Incident Commander has retained the responsibility for Information, Safety and Liaison, as well as for Finance/Administration and all of that section's responsibilities. The Planning Section Chief has not filled any of the sub-elements. The Logistics Section Chief has filled the Service and Support Branch positions. Neither of the branches have filled positions below them on the chart.

Command Staff

There are four positions assigned to incident command: the Incident Commander, Information Officer, Safety Officer, and Liaison Officer.

FILLING POSITIONS AND DELEGATING RESPONSIBILITY

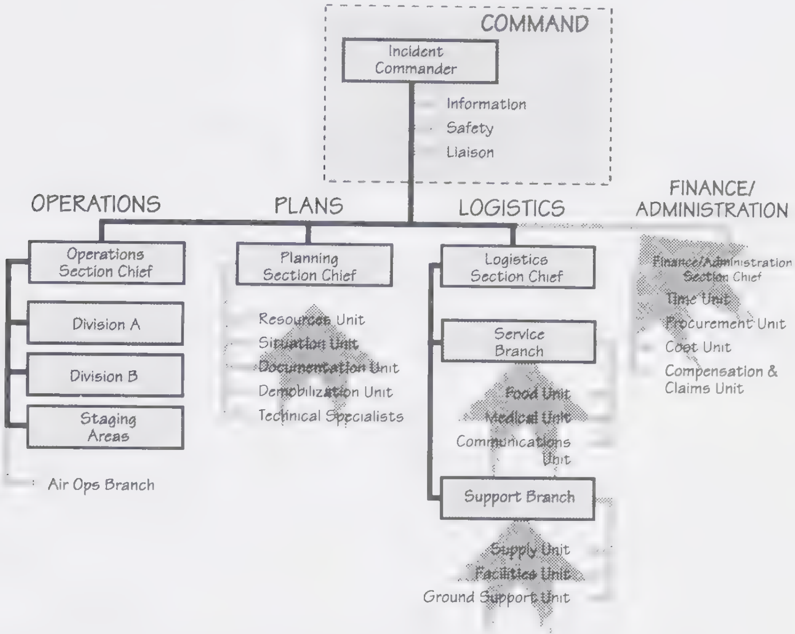

COMMAND
Incident Commander
Information
Safety
Liaison
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Division A
Division B
Staging Areas
Air Ops Branch
Planning Section Chief
Resources Unit
Situation Unit
Documentation Unit
Demobilization Unit
Technical Specialists
Logistics Section Chief
Service Branch
Food Unit
Medical Unit
Communications Unit
Support Branch
Supply Unit
Facilities Unit
Ground Support Unit
Finance/Administration Section Chief
Time Unit
Procurement Unit
Cost Unit
Compensation & Claims Unit

Figure 7.3 This incident is being managed by nine positions. Until a position is filled, the position above it retains the responsibility.

Command provides the overall control of the incident.

Incident Commander - The Incident Commander is the person in charge of and responsible for the management of the incident. The Incident Commander is commonly referred to on the radio as the "IC," preceded by the incident name: "Highway 65 IC." (Note: ICS position titles are used instead of agency radio call signs or personal names.) The IC draws his or her authority from the agency responsible for the incident, and is directly responsible to the agency line officer. The agency representative may be the Forest Supervisor, Fire Chief, Mayor, etc.

ICS positions should be filled only when they are needed.

As stated before, this position is the only one that is required to be filled under the Incident Command System. An initial organizational scheme may be quite simple; an Incident Commander and several resources (Figure 7.4). The Incident Commander fills positions in the organization chart, as necessary. It is very important that the IC be qualified for that position. It is common that as the incident grows in complexity, the person filling the IC's role may change. As this change in command takes

A TYPICAL INITIAL
ORGANIZATIONAL SCHEME

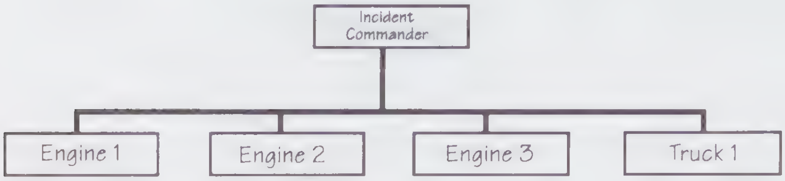


Figure 7.4 A first alarm assignment or the initial attack force may all answer to the Incident Commander. A need for other positions has not yet been identified, so the positions have not been filled.

Even a small incident should be run under ICS. You just don't fill all the boxes.

place, the new IC must be fully briefed on the status of the incident. The change in command is also announced over the radio so that everyone knows who is in charge.

Besides the four section chiefs, there are three other positions that answer directly to the Incident Commander. These three officers constitute the **Command Staff** (Figure 7.5). None of these positions are authorized deputies, but they can have assistance assigned as needed. (Note: A deputy is an individual that is fully qualified to manage the function of his/her superior. An assistant is a helper or subordinate.)

The Information Officer provides a central focus and contact point for the media.

Information Officer - The Information Officer is the central focus and contact point for the media or other organizations seeking information related to the incident. Only one Information Officer is assigned to an incident; this cuts down on confusion and conflicting information. On a more complex incident, the Information Officer may have several Assistant Information Officers.

The Safety Officer provides overall review of safety on the incident.

Safety Officer - The Safety Officer monitors the overall incident operations to ensure that safety is not being compromised. Only one Safety Officer is assigned to an incident, but this position may have several assistants who are assigned to monitor operations in the various functions or operating divisions. Even though the Safety Officer is a staff function, he/she may exercise emergency authority to directly stop unsafe acts if personnel are in imminent, life-threatening danger.

Liaison Officer - The Liaison Officer is responsible for coordinating involvement with representatives from assisting agencies. Other agencies or jurisdictions will often send resources to assist at an incident. These assisting agencies may also send an **Agency Representative** to work with the incident management team as a coordinator. The Liaison Officer does not direct the operations of these other agencies, but rather serves as a liaison between the Incident Commander and the various Agency Representatives.

The Liaison Officer is the contact point for assisting agency representatives.

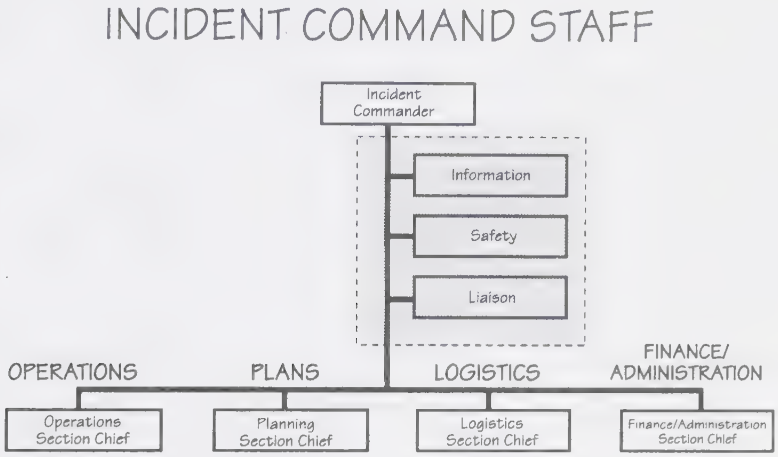

INCIDENT COMMAND STAFF
Incident Commander
Information
Safety
Liaison
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.5 The Command Staff is made up of three positions: Information Officer, Safety Officer, and Liaison Officer. These positions are usually filled as the incident grows in complexity. There may be a need to assign assistants for each of the officers.

General Staff

The key staff functions are managed by Section Chiefs who answer directly to the Incident Commander. These four positions are referred to as the **General Staff** (Figure 7.6). They can either provide relief or be assigned specific functions. On large incidents, especially where multiple agencies or jurisdictions are involved, the use of personnel

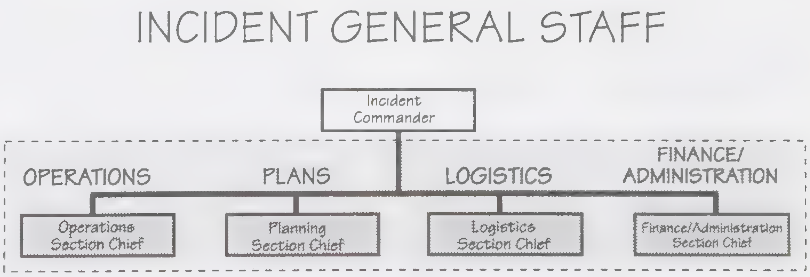

INCIDENT GENERAL STAFF
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.6 The General Staff is made up of the four Section Chiefs. Each of these key positions are authorized deputies to assist them in the performance of their responsibilities.

from the other agencies can greatly increase intra-agency coordination.

The Operations Section Chief is responsible for all operational aspects of an incident.

The operations section is where all the work to abate the hazard or fight the fire is done. Until an Operations Section Chief is assigned, the Incident Commander is responsible for managing the tactical field operations.

Operations Section Chief

The Operations Section Chief answers directly to the Incident Commander and is responsible for the implementation of the incident's action plan. As a member of the General Staff, the Operations Section Chief is authorized to have a deputy.

A division is a geographic area of an incident. On a wildland fire, it is a section of fireline. On a high-rise fire, a division is a floor of the building.

If the incident involves several jurisdictions, you may want to assign a representative from another agency as a deputy to the Operations Section Chief. This will help with coordination and provide relief for this very important position.

One of the first actions that should be taken in organizing a wildland fire is to divide it into divisions and/or groups (Figure 7.7). This changes the traditional "pinwheel" shaped organizational scheme into one with a clear separation of responsibility (Figure 7.8). The number of divisions and/or groups on an incident is dictated by the incident's size or complexity. If the incident grows to the point where more than five divisions are needed, branches become part of the organizational scheme. The goal is to keep the organization as simple and as streamlined as possible, while maintaining a reasonable span of control.

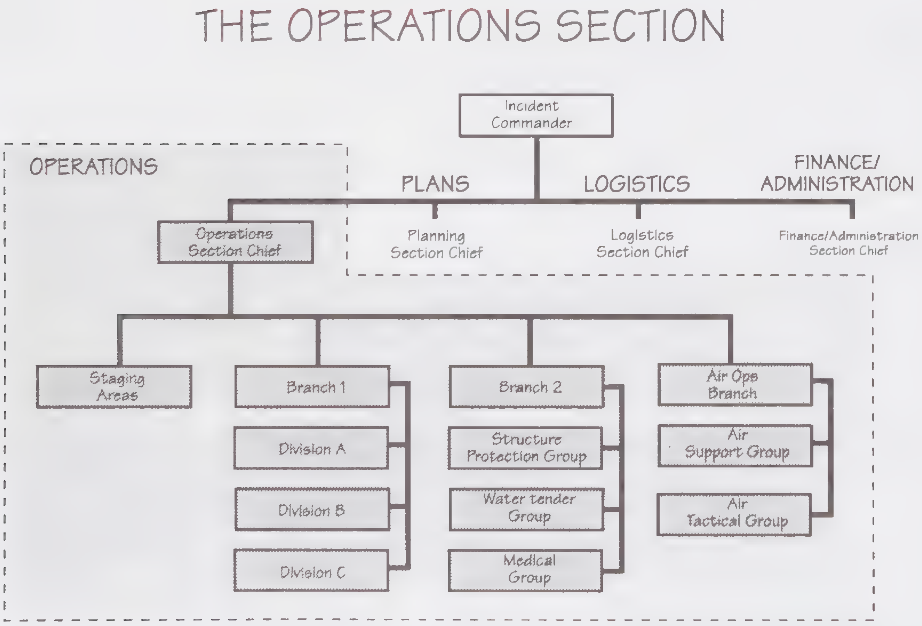
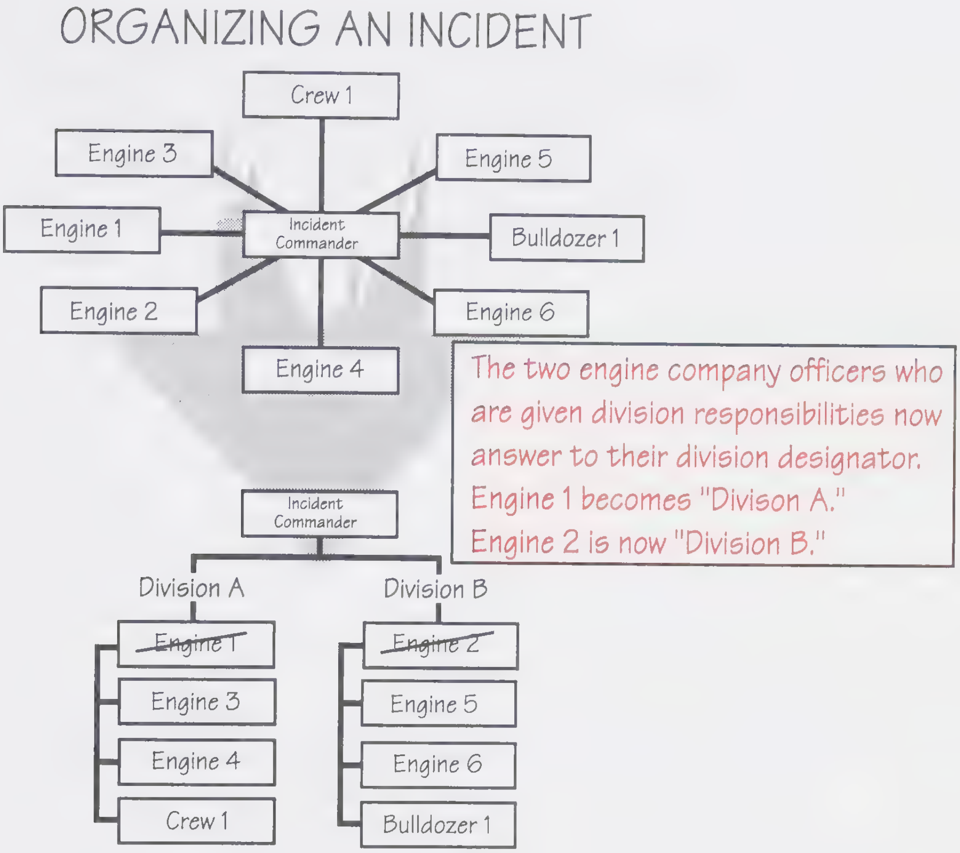

THE OPERATIONS SECTION
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Staging Areas
Branch 1
Division A
Division B
Division C
Branch 2
Structure Protection Group
Water tender Group
Medical Group
Air Ops Branch
Air Support Group
Air Tactical Group

Figure 7.7 The Operations Section can include divisions, groups and branches. These are used to organize the incident into geographic or functional areas. Air Operations and Staging also are managed by the Operations Section Chief.


ORGANIZING AN INCIDENT
Crew 1
Engine 3
Engine 5
Engine 1
Incident Commander
Bulldozer 1
Engine 2
Engine 6
Engine 4
Incident Commander
Division A
Division B
~~Engine 1~~
Engine 3
Engine 4
Crew 1
~~Engine 2~~
Engine 5
Engine 6
Bulldozer 1

The two engine company officers who are given division responsibilities now answer to their division designator. Engine 1 becomes "Divison A." Engine 2 is now "Division B."

Figure 7.8 The establishment of divisions is the first step in organizing a developing wildland fire.

Establish divisions early in the incident.

Divisions - A division is managed by a Division/Group Supervisor. This position generally answers to the Operations Section Chief. However, if branches are established the Division/Group Supervisor answers to the Branch Director. Divisions are used to divide an incident geographically, for example, by miles of fireline in a wildland fire, or by floors in a high-rise fire. If the division is an area of a wildland fire, it is given an alpha designator ("Division A," "Division R," etc.). If it is a floor in a high-rise building, the floor number ("Division 14," "Division 42," etc.) is used.

Groups are functional elements of operations. Examples of groups are: structural protection groups, medical groups, water tender groups, etc.

Groups - Groups are established to describe functional areas of the operation, like a "structure protection group" or a "medical group." They are managed by a Division/Group Supervisor and are on the same level in the organization as a division (Figure 7.9).

Groups and divisions can function in the same area, but one does not supervise the other. When a functional group is working within a division, the two supervisors must coordinate their activities. Division and Group Supervisors report to the Incident Commander, or to the Operations Section Chief/Branch Director if these positions are filled. Deputies are not used at the division or group level.

Groups do not work for Division Supervisors. They work with them.

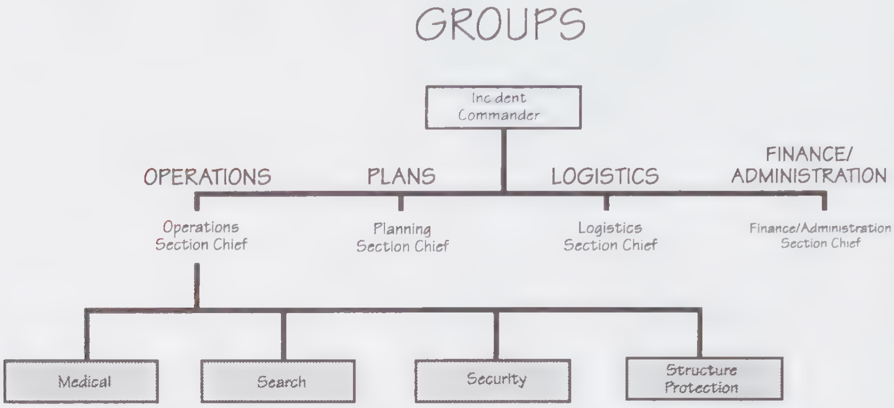

GROUPS
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Medical
Search
Security
Structure Protection

Figure 7.9 Groups are established for the management of functional activities, like structure protection, medical response and search and rescue.

When there are more than five divisions on a fire, establish branches.

Some agencies have expanded the use of groups to manage resources that can be shared, like water tenders. A Water Tender Group Supervisor is given control of all the water tenders either on a single branch or on the entire incident. Division Supervisors who need a water tender can coordinate their needs with the Water Tender Group. This coordination can increase the efficiency and effectiveness of these type of resources.

Span of Control is the supervisory ratio of from three to seven individuals with five being established as optimum.

Branches - As an incident develops, the number of divisions will also increase. If more than five divisions are required, you may need to establish branches. There are three reasons to establish branches:

- **Span of Control** - One person can effectively manage between three and seven reporting elements, depending on the complexity of the incident. The recommended span of control is one to five. If the number of reporting elements falls outside the three to seven range, expansion or consolidation of the organization may be necessary.

- **Functional Branch Structure** - Some incidents involve multiple disciplines (e.g., structure protection, police, medical) and, as such, may require the use of a functional branch structure.
- **Multi-jurisdictional Incident** - If several jurisdictions or agencies are involved with an incident, it may be better to use branches for each of the involved entities.

Each branch that is activated will have a Branch Director assigned; deputies may be used at the branch level.

Establish a staging area early in the incident.

Air Operations - Air Operations, if activated, functions at the branch level in the organization. The Air Operations Branch Director is responsible for the tactical operations of all aircraft assigned to the incident, as well as their logistical support.

Staging Areas - Staging Areas are established whenever it is necessary to position resources awaiting assignment. A Staging Area Manager is assigned to manage each of the staging areas. The manager answers to the operations side of the incident. All resources in the Staging Area are "assigned" to staging and should be ready for deployment. There should be a three minute response time for resources assigned to staging. Staging Areas should not be used to park out-of-service resources or for logistics functions. Staging should be one of the first elements of ICS that is established on a developing wildland fire.

The Planning Section Chief is responsible for developing the Incident Action Plan from information provided by operations personnel.

Planning Section Chief

The Planning Section is managed by the Planning Section Chief. The primary function of this section is to develop the Incident Action Plan for each operational period, keep track of the status of all assigned resources, and track the fire. There are several sub-elements within the Planning Section: the Resources Unit, Situation Unit, Documentation Unit, Demobilization Unit, and Technical Specialists (Figure 7.10).

The Planning Section should anticipate potential problems.

The first responsibility of the Planning Section is to "check-in" all of the resources. Other tasks that the Planning Section Chief is responsible for include:

- Maintaining and displaying information on resources and situation status.

Resource and Situation Status is the responsibility of the Planning Section.

- Preparing the Incident Action Plan.
- Developing the Demobilization Plan.
- Providing technical specialists as needed.

One of the most important functions of the Planning Section is to anticipate potential problems and events that may come up beyond the current operational period.

Resources Unit - Is responsible for all check-in activity, and for maintaining the status of all personnel and equipment resources assigned to the incident.

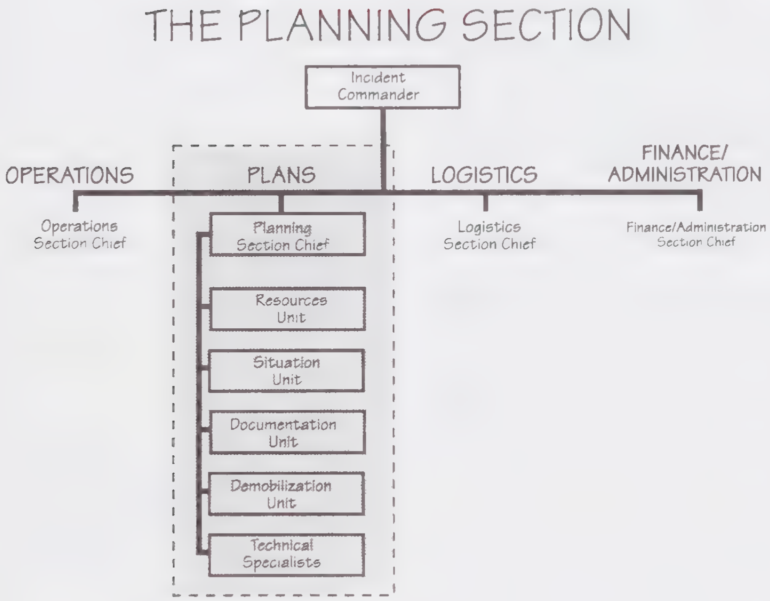

THE PLANNING SECTION
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Resources Unit
Situation Unit
Documentation Unit
Demobilization Unit
Technical Specialists

Figure 7.10 The Planning Section is responsible for maintaining and displaying resources and situation status, preparing the Incident Action Plan, developing the Demobilization Plan, and providing technical specialists as needed.

Situation Unit - Collects and processes information on the current situation, prepares situation status displays and situation summaries and develops maps and projections.

Documentation Unit - Prepares the Incident Action Plan, maintains all incident-related documentation, and provides duplication services.

Demobilization Unit - On large, complex incidents, the Demobilization Unit assists in ensuring that an orderly, safe, and cost-effective release of personnel will be made when they are no longer required at the incident.

Technical Specialists - Technical specialists are advisors with special skills that may be required at the incident. Technical specialists initially report to the Planning Section. They may continue to work within the Planning Section or may be reassigned to another part of the organization. Technical specialists can be in any discipline required (e.g., aviation, hand crew usage, environment, water supply, hazardous materials).

The Logistics Section is responsible for providing all services and support.

Logistics Section Chief

The Logistics Section is responsible for all the services and support needs of an incident, including obtaining and maintaining essential personnel, facilities, equipment, and supplies (Figure 7.11). Logistics, services, and support are very important and often underappreciated. Early recognition of the need to establish logistics support can reduce time and costs.

The Logistics Section is managed by a Logistics Section Chief who answers directly to the Incident Commander. A deputy position is authorized and if the workload dictates, two branches can be established, one for support and the other for services. There are six functional units within the Logistics Section: Communications Unit, Medical Unit, Food Unit, Supply Unit, Facilities Unit, and the Ground Support Unit.

The following units are within the **Service Branch**, if one is established. Otherwise, they report directly to the Logistics Section Chief.

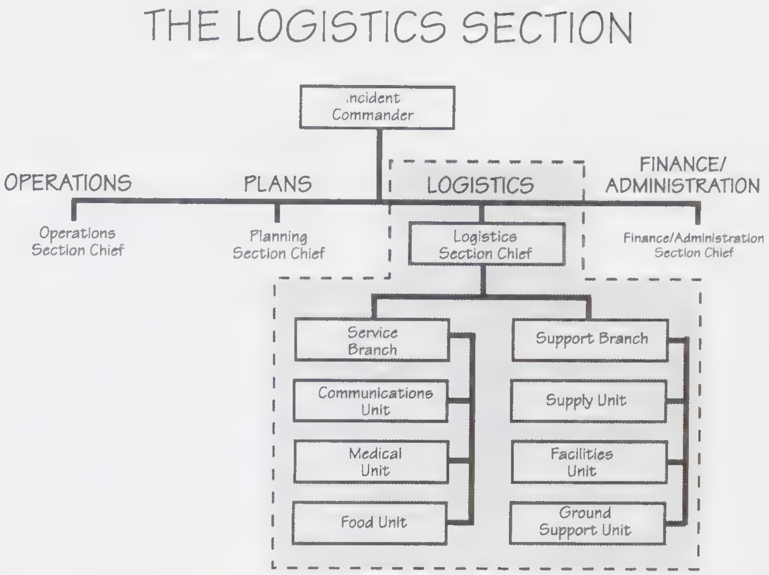

THE LOGISTICS SECTION
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Service Branch
Support Branch
Communications Unit
Supply Unit
Medical Unit
Facilities Unit
Food Unit
Ground Support Unit

Figure 7.11 The Logistics Section has six functional units: Communications Unit, Medical Unit, Food Unit, Supply Unit, Facilities Unit, and the Ground Support Unit.

Communications Unit - Develops the Communications Plan, distributes and maintains all communications equipment, and manages the Incident Communications Center.

Medical Unit - Develops the Medical Plan, and provides first-aid for personnel assigned to the incident. This unit also develops the Emergency Medical Transportation Plan (ground and/or air) and prepares medical reports.

Service and Support Branches are established as the incident organization grows in complexity.

Food Unit - Ensures that all personnel committed to the fire have adequate food and drinking water. The unit may prepare menus and food, provide food through catering services, or use some combination of both methods.

The following units are within the **Support Branch**, if one is established. Otherwise, they report directly to the Logistics Section Chief.

Supply Unit - Orders personnel, equipment, and supplies. The unit stores and maintains supplies, and services non-expendable equipment. All resource orders are placed through this unit. If this unit is not established, the responsibility for ordering rests with the Logistics Section Chief.

Facilities Unit - Sets up and maintains whatever facilities may be required in support of the incident. It provides managers for the Incident Base and camps and provides security support for the facilities and incident as required.

Ground Support Unit - Provides transportation, and maintains and fuels vehicles assigned to the incident.

Finance/Administration Section Chief

The Finance/Administration Section is responsible for monitoring incident-related costs, and administering any necessary procurement contracts. The incident doesn't have to be large to require some level of finance/administrative support. If the Finance/Administration Section is established, there are four units that may be activated: Time Unit, Procurement Unit, Compensation/Claims Unit, and Cost Unit (Figure 7.12).

All of the bills are paid by the Finance/ Administration Section.

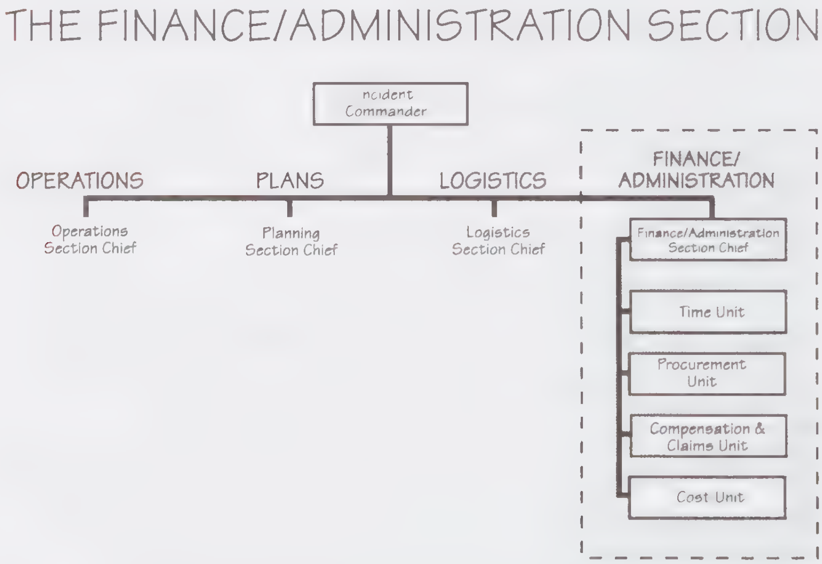

THE FINANCE/ADMINISTRATION SECTION
ncident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Time Unit
Procurement Unit
Compensation & Claims Unit
Cost Unit

Figure 7.12 The Finance/Administration Section is responsible for all cost related and administrative services on the incident.

The Finance/Administration Section Chief is responsible for all cost related activities on the incident. A deputy is authorized, if needed.

Time Unit - Ensures that all personnel time on an incident is recorded.

Procurement Unit - Processes administrative paperwork associated with equipment rental and supply contracts. Responsible for equipment time reporting.

Compensation/Claims Unit - Is responsible for seeing that all documentation related to workers compensation is correctly completed. This unit also maintains files of injuries and/or illnesses associated with the incident. It also handles investigation of all claims involving damaged property associated with or involved in the incident.

Cost Unit - Responsible for collecting all cost information, and for providing cost estimates and cost savings recommendations.

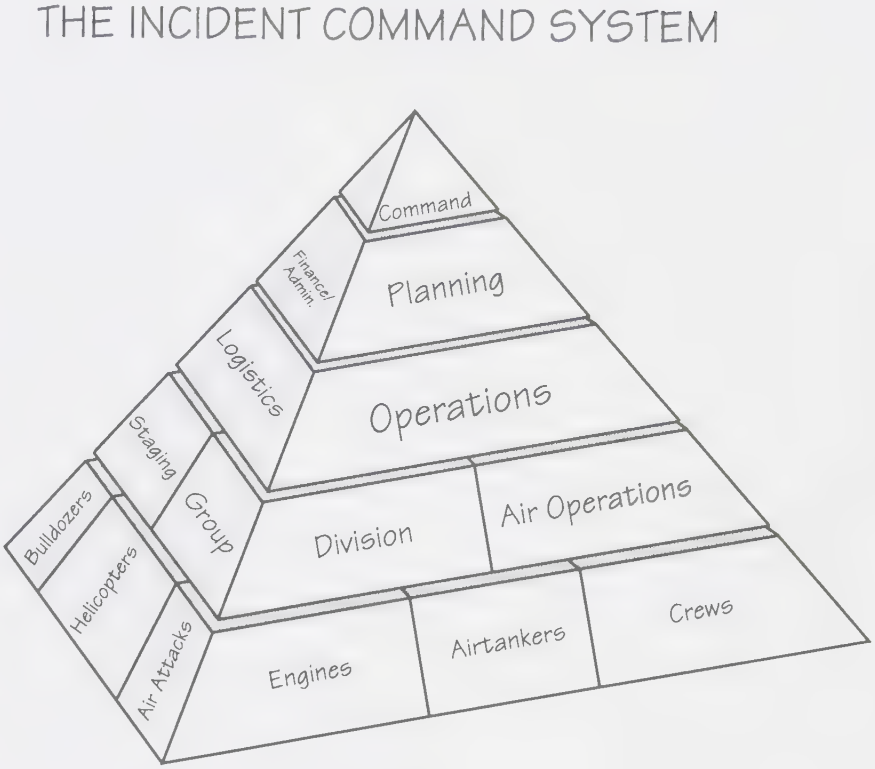

THE INCIDENT COMMAND SYSTEM
Command
Finance/ Admin.
Planning
Logistics
Operations
Staging
Group
Division
Air Operations
Bulldozers
Helicopters
Air Attacks
Engines
Airtankers
Crews

Figure 7.13 The Incident Command System "pyramid" of authority and responsibility. Be sure you tailor the size of the organization to the needs of the incident.

The positions described on the previous pages form the basic building blocks of the Incident Command System. Once you become familiar with these basic building blocks you can use them to build an organization able to respond to the needs of an emergency (Figure 7.13). The key to using the Incident Command System is to balance the needs dictated by the emergency with the size of the organization. It is easy to over staff an organization to such a level that it will actually hinder operations.

ORGANIZATION TERMINOLOGY

Primary Position	Title	Support Position	Radio Call
Incident Commander	Incident Commander	Deputy	"Point IC"
Command Staff	Officer	Assistant	"Point Safety"
Section	Chief	Deputy	"Point Operations"
Branch	Director	Deputy	"Branch 1"
Division/Group	Supervisor	**	"Division D" "Structure Protection Group"
Strike Team/Task Force	Leader	**	"Strike Team 9441" "Task Force 6"
Unit	Leader	Manager	"Point Supply Unit Leader"
Single Resource	use unit ID	**	"ORCO Engine 22"

** A support or deputy position is not authorized or not applicable.

Figure 7.14 Each primary position within ICS has specific titles. Most upper-level positions are authorized to have support or deputy positions.

As you can see, the primary functions at each level of the ICS organization have distinctive titles (Figure 7.14). When used on the radio, each position title is prefaced with the name of the incident (e.g., "Deer Valley Operations," "Point IC," etc.).

There should be only one command post.

Incident Facilities

As an incident grows, several facilities or sites must be established and identified. The Incident Command System includes six such facilities: Incident Command Post, Staging Areas, Incident Base, Camps, Helibase, and Helispots (Figure 7.15). There is only one Incident Command Post and one base per incident. There can be as many of the other facilities as necessary for the smooth operation of the incident.

Incident Command Post

The Incident Command Post (ICP) is where the Incident Commander and key staff functions work. More importantly, it is where these functions can be found. Since every incident will have an Incident Commander, every incident will have an ICP. This may be in the form of a vehicle, trailer, tent, or rented building.

Having one ICP is critical when the incident involves more than one agency or jurisdiction. If the various agencies and/or jurisdictions are separated, it is hard to have an effective Unified Command.

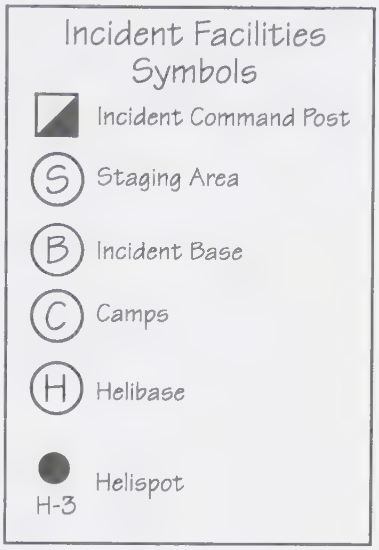


Figure 7.15 There are standard symbols used to identify each of the facilities on maps.

The ICP can be located with other incident functions. It should be close to the incident communications center and the planning function. The site should be large enough to accommodate the anticipated needs for the incident and ICP functions. It should be located away from noise and incident-generated traffic. It should be sheltered from the weather and be secure from public traffic.

There are general guidelines for the establishment of an ICP. The ICP should be:

- Positioned away from the general noise and confusion associated with the incident.
- Positioned outside the present and potential hazard zone.
- Have the ability to expand as the incident grows.
- Have the ability to provide security, and to control access to the ICP as necessary.
- Identified by a distinctive banner or sign.

Staging is a function under Operations.

Announce ICP activation and location via radio or other communication so all appropriate personnel are notified.

Staging Areas

Staging Areas are locations where personnel and equipment are kept (or staged) while awaiting tactical assignments. They provide a point to which dispatched resources can report and from which specific assignments can be made. Staging Areas are managed by a Staging Area Manager. Staging Areas are within the Operations Section, thus the resources assigned to staging are under the control of the Operations Section Chief. As an incident grows, there may be a need to establish more than one Staging Area.

Some of the specific benefits of Staging Areas are that they:

- Provide a safe location for resources to wait for assignments.
- Provide for greater accountability by having available personnel and resources together in one location.
- Prevent resources from free-lancing or doing their own thing.
- Minimize the need for excessive communications of resources calling for assignment.
- Control and assist in check-in of personnel who arrive at the incident via privately owned vehicles or other private means.
- Allow the Operations Section Chief (or IC) to properly plan for resource use, and to provide for contingencies.
- Reduce traffic congestion.

You may want to establish different staging areas for different types of resources.

A Staging Area may be in the same general area or adjacent to other incident facilities; however, it should have its own separate location and name. You may want to set up separate Staging Areas for different kinds of resources, for example, fire equipment and personnel in one area and police-related resources in another. You want the areas to be easily found, but you want them off the main traffic routes so that the public isn't asking why all that equipment is just sitting there; rather than "fighting the fire."

The following are some other considerations for establishing staging areas:

- They should be close to the location of tactical assignments (hopefully within 5 minutes of the action).
- They must be located in a safe area (for example, upwind from a hazardous materials spill or out of the path of a fast moving wildland fire).
- They should have separate ingress/egress routes. You don't want to create a traffic jam by having incoming and outgoing resources on the same road.
- They should be large enough to accommodate anticipated levels of resources and should be located in an area where vehicles and personnel will do minimal environmental damage.

- They should be clearly marked.
- Personnel assigned to staging should be flexible. It may be necessary to relocate staging areas to facilitate the needs of the incident or to protect personnel from approaching danger.

Incident Base is under the Logistics Section.

Incident Base

The Incident Base is the location at which the primary service and support activities are performed. In the old days, it was called the "fire camp." Not all incidents require the establishment of an Incident Base. If a base is established, this is where the Logistics Section is located. There should be only one base for an incident. Normally, the Incident Base is where all uncommitted (out-of-service or resting) equipment and personnel are located. If the incident is large, additional logistic support sites, or camps, can be established.

The management of the base falls under the Logistics Section. If an Incident Base is established, a Base Manager will be designated. The Base Manager in a fully activated ICS organization will be in the Facilities Unit.

There is only one Incident Base, but there can be several camps.

Camps

Camps are locations which are equipped and staffed to provide sleeping, food, water, and sanitary services to personnel assigned to an incident. Camps are established when the travel time is too long or number of personnel needing support is too great to be serviced at the Incident Base. All services and functional activities performed at a base may also be located or performed at camps.

Camp Managers are responsible for managing the camp, and for providing nontechnical coordination of all organizational units operating within the camp. The Camp Manager reports to the Facilities Unit Leader in the Logistics Section.

Helibase

The Helibase is the main location within the general incident area for parking, fueling, maintenance, and loading of helicopters. It is often located at or near the Incident Base, at a nearby airport, or other convenient site. If located near the Incident Base, ensure that the noise and dust will not interfere with the base operations.

The Helibase Manager reports to the Air Support Group Leader, the Air Operations Branch Director, or the Operations Section Chief, depending on the organizational structure.

Helispot

Helispots are temporary locations which helicopters can safely operate out of. They can be used to load and off-load personnel, equipment, and supplies. Helispots are managed by Helispot Managers who report to the Helibase Manager. If an incident has no established air operations organization, but does have one or more helispots, the Helispot Manager reports to the Operations Section Chief.

The Incident Objectives are broad statements of intent.

Incident Planning

Incident planning actually starts with the arrival of the first firefighter on a fire. One of the first items of business for this firefighter, or Incident Commander, is to establish Incident Objectives—broad statements of intent. Some examples are, "keep the fire south of Highway 32, east of the community of Forest Ranch, north of Honey Run Road, and cut it off to the west when an opportunity presents itself." These objectives then set the direction for the firefight until the fire is controlled, or the situation dictates that the objectives be modified.

The Incident Briefing format should be used by all Initial Attack Incident Commanders.

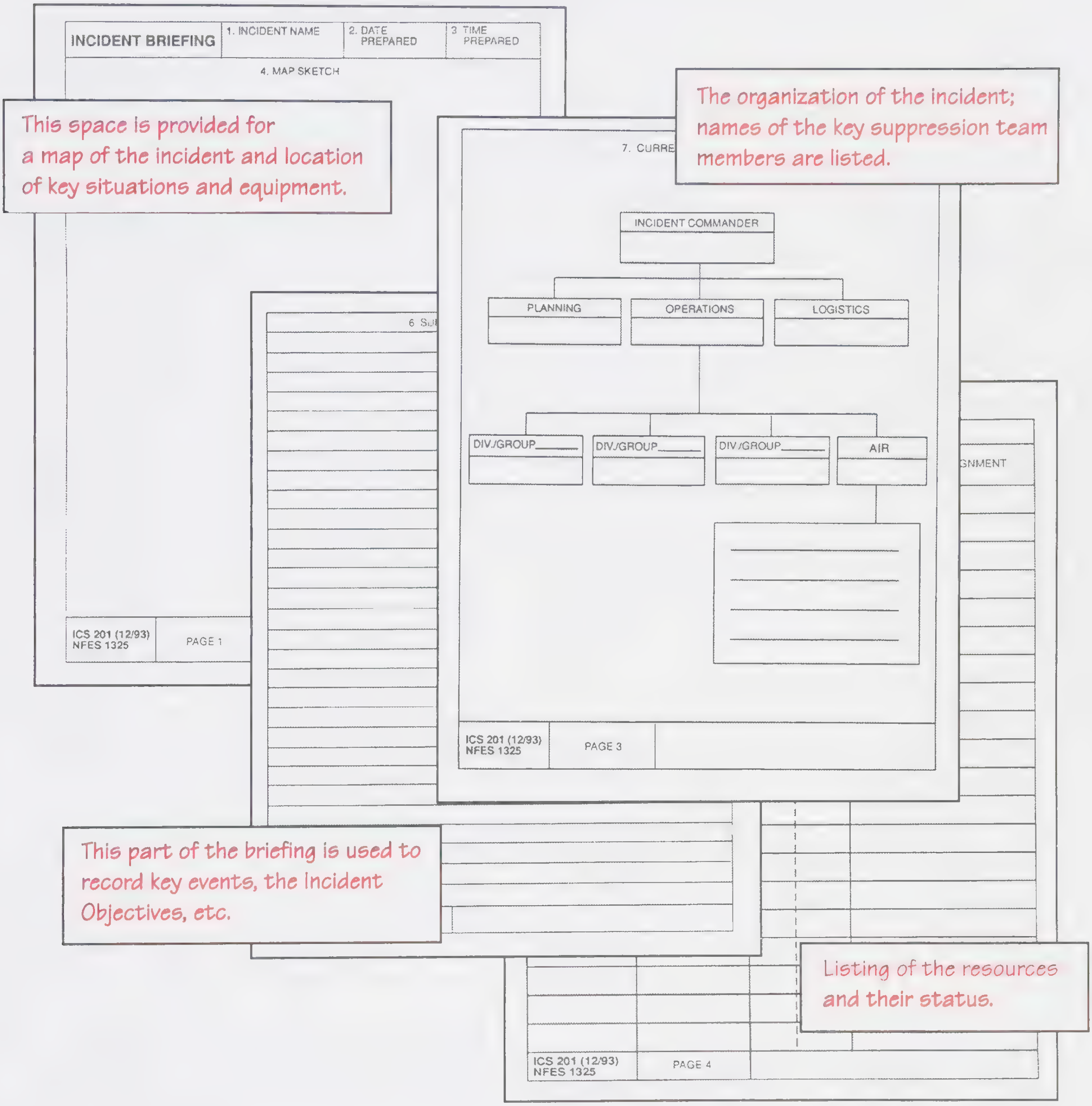
The plan can be given as oral instructions, but it is better if it is written. Written plans are essential so that all levels of a growing incident and organization have a clear understanding of the tactical actions.

Incident Briefing

The Incident Command System provides a planning document for the development of the plan, objectives, and the management of the incident in its initial attack period. It is the ICS Incident Briefing (Form 201). See Figure 7.16.

The planning document must reflect the needs as identified by the Division/Group Supervisors and Operations Section Chief,

INCIDENT BRIEFING DOCUMENT


INCIDENT BRIEFING
1. INCIDENT NAME
2. DATE PREPARED
3. TIME PREPARED
4. MAP SKETCH
ICS 201 (12/93) NFES 1325
PAGE 1
6. SU
7. CURRE
INCIDENT COMMANDER
PLANNING
OPERATIONS
LOGISTICS
DIV./GROUP
DIV./GROUP
DIV./GROUP
AIR
ICS 201 (12/93) NFES 1325
PAGE 3
GNMENT
ICS 201 (12/93) NFES 1325
PAGE 4

This space is provided for a map of the incident and location of key situations and equipment.

The organization of the incident; names of the key suppression team members are listed.

This part of the briefing is used to record key events, the Incident Objectives, etc.

Listing of the resources and their status.

Figure 7.16 Incident Briefing Form (ICS Form 201) is used to organize the incident in its initial attack phase.

and must be completed far enough in advance of each operational period to ensure that requested resources are available when needed. Large incidents should have a written Incident Action

Plan. Several standardized forms have been developed to aid in the preparation of the plan.

Incident Action Plan

The Incident Action Plan is the script for the operation.

The Incident Action Plan is the document that provides all supervisory personnel with information about the incident and how it will be managed for a specific period of time called the operational period. The written plan should provide a clear statement of the objectives and actions, the basis for measuring work effectiveness and cost effectiveness, and a way to measure progress and accountability. There are several important pieces to this plan: the Incident Objectives; the Incident Organization; the various assignment lists; weather and safety statements; and other supporting material, such as a Communications and Medical Plan, a Traffic Plan, etc. It is the responsibility of the Planning Section Chief and staff to prepare an Incident Action Plan for each operational period. The plan is then used as the script for each shift briefing.

There may be times when it seems like the person who developed the plan was on another fire, or didn't know what was really going on with this one. It is vital that the planners have a good understanding of the situation. To meet this requirement, planners need to know:

- What has happened to date?
- What progress has been made?
- How good is the current plan?
- What is the incident growth potential?
- What is the present and future resource and organizational capability?

It is especially important that planners know **in advance** what the likelihood is of obtaining additional resources support from outside sources, for use in the next operational period. If there are readily available resources of the proper kind and type, then the planning process can encompass a wider variety of potential strategies than would be possible under very limited resource constraints.

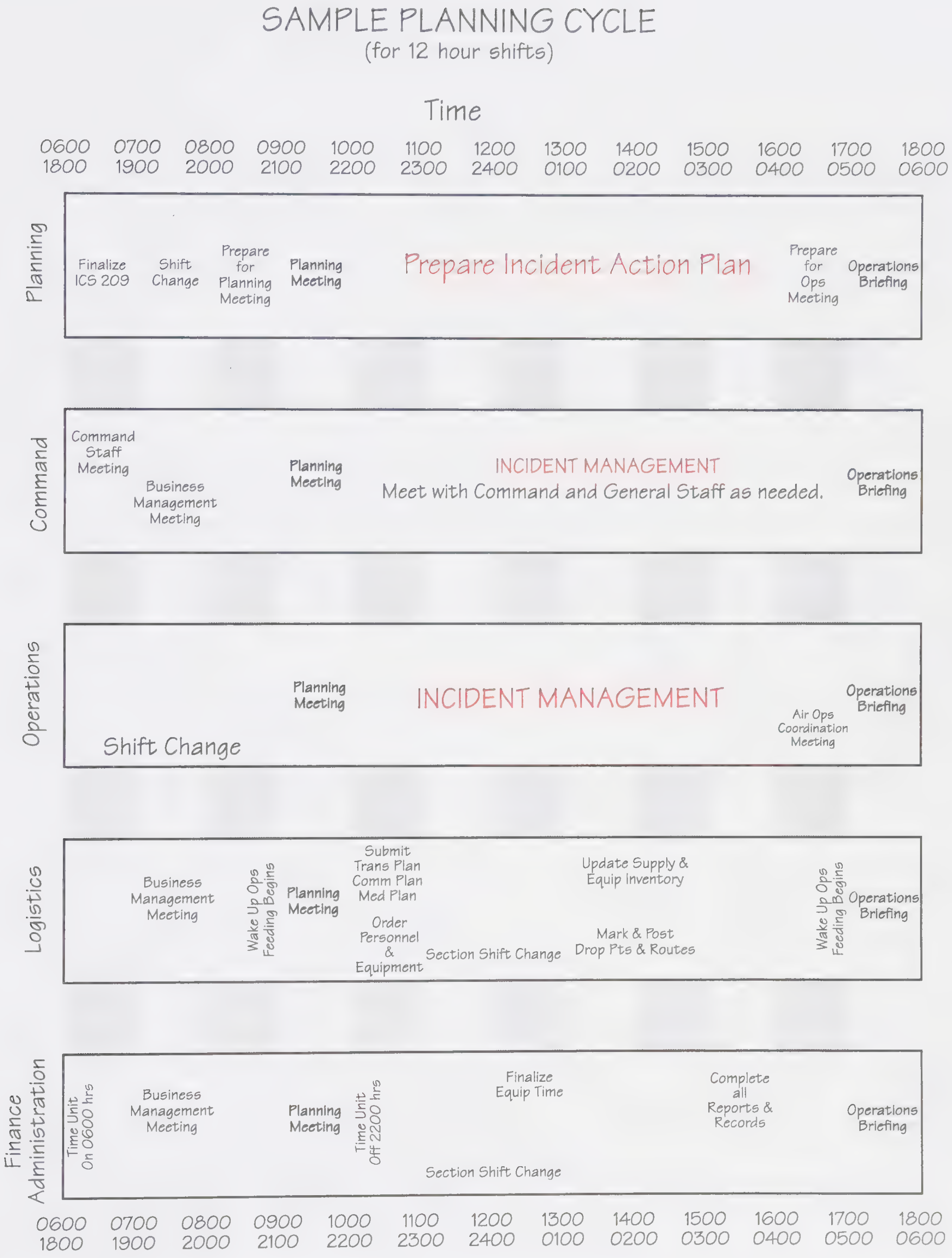

SAMPLE PLANNING CYCLE
(for 12 hour shifts)
Time
0600 1800
0700 1900
0800 2000
0900 2100
1000 2200
1100 2300
1200 2400
1300 0100
1400 0200
1500 0300
1600 0400
1700 0500
1800 0600
Planning
Finalize ICS 209
Shift Change
Prepare for Planning Meeting
Planning Meeting
Prepare Incident Action Plan
Prepare for Ops Meeting
Operations Briefing
Command
Command Staff Meeting
Business Management Meeting
Planning Meeting
INCIDENT MANAGEMENT
Meet with Command and General Staff as needed.
Operations Briefing
Operations
Shift Change
Planning Meeting
INCIDENT MANAGEMENT
Air Ops Coordination Meeting
Operations Briefing
Logistics
Business Management Meeting
Wake Up Ops Feeding Begins
Planning Meeting
Submit Trans Plan Comm Plan Med Plan
Order Personnel & Equipment
Section Shift Change
Update Supply & Equip Inventory
Mark & Post Drop Pts & Routes
Wake Up Ops Feeding Begins
Operations Briefing
Finance Administration
Time Unit On 0600 hrs
Business Management Meeting
Planning Meeting
Time Unit Off 2200 hrs
Finalize Equip Time
Section Shift Change
Complete all Reports & Records
Operations Briefing
0600 1800
0700 1900
0800 2000
0900 2100
1000 2200
1100 2300
1200 2400
1300 0100
1400 0200
1500 0300
1600 0400
1700 0500
1800 0600

Figure 7.17 Sample planning cycle for a 12-hour operational shift.

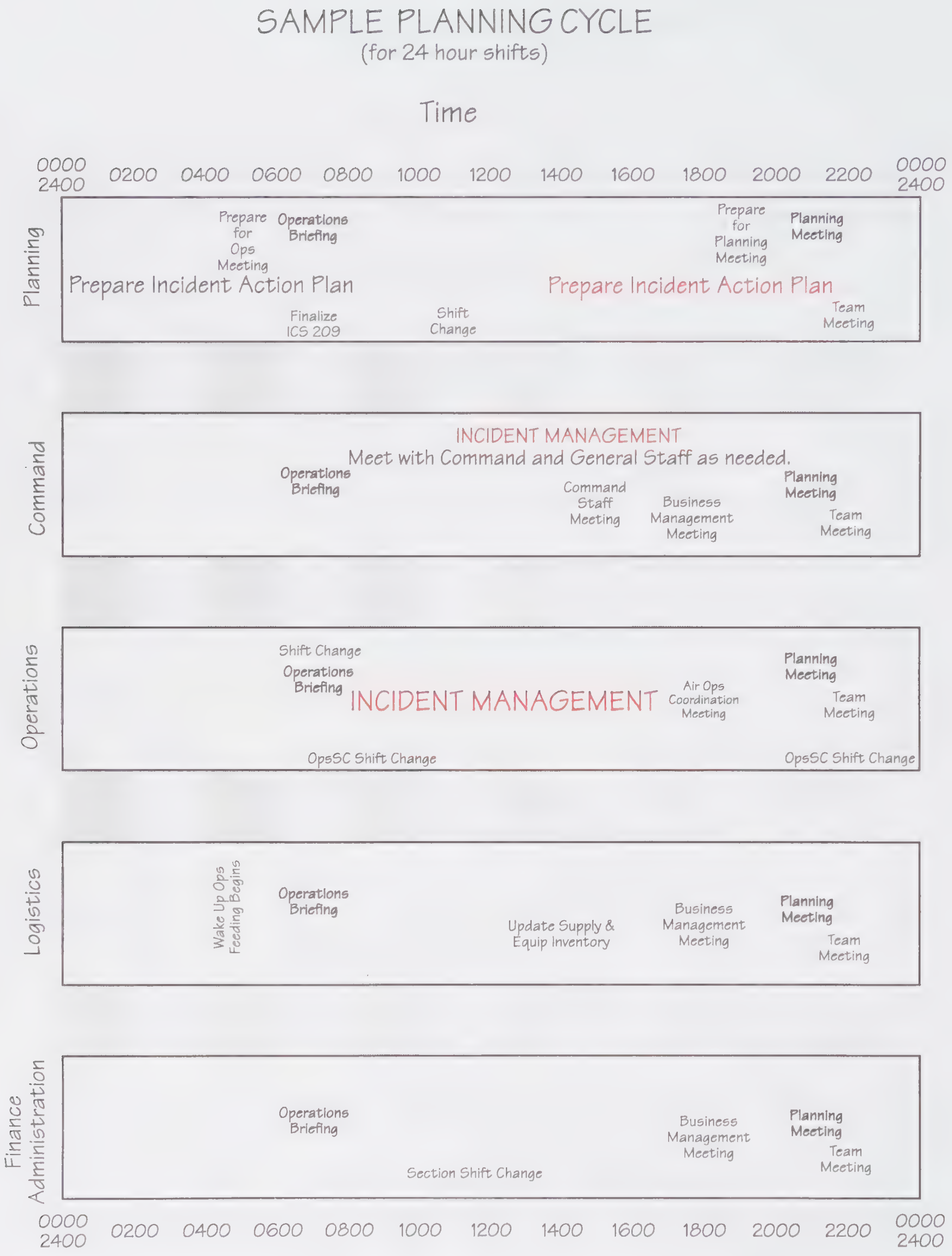

SAMPLE PLANNING CYCLE
(for 24 hour shifts)
Time
0000 2400
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
0000 2400
Planning
Prepare for Ops Meeting
Operations Briefing
Prepare for Planning Meeting
Planning Meeting
Prepare Incident Action Plan
Prepare Incident Action Plan
Finalize ICS 209
Shift Change
Team Meeting
Command
INCIDENT MANAGEMENT
Meet with Command and General Staff as needed.
Operations Briefing
Command Staff Meeting
Business Management Meeting
Planning Meeting
Team Meeting
Operations
Shift Change
Operations Briefing
INCIDENT MANAGEMENT
Air Ops Coordination Meeting
Planning Meeting
Team Meeting
OpsSC Shift Change
OpsSC Shift Change
Logistics
Wake Up Ops Feeding Begins
Operations Briefing
Update Supply & Equip Inventory
Business Management Meeting
Planning Meeting
Team Meeting
Finance Administration
Operations Briefing
Section Shift Change
Business Management Meeting
Planning Meeting
Team Meeting
0000 2400
0200
0400
0600
0800
1000
1200
1400
1600
1800
2000
2200
0000 2400

Figure 7.18 Sample planning cycle for a 24-hour operational shift.

The Incident Commander has several operational shift schemes to choose from. There is the traditional 12-hour shift, a 16-hour daylight only shift, or a 24-hour shift. Each has advantages and disadvantages. The selection of the operational shift not only sets the time schedule for field operations, but it also sets the planning cycle. Figure 7.17 outlines the planning cycle for a 12-hour shift and Figure 7.18 outlines the planning cycle for a 24-hour shift.

Make the planning briefing meaningful. Don't let it drag on.

Before you start developing the Incident Action Plan, the Planning Section Chief should conduct a planning meeting. During this meeting, various members of the General Staff and Command Staff will contribute to developing the framework for the plan (Figure 7.19).

It is important that prior to the planning meeting, intra-agency negotiations on the use of resources, strategies, and cost issues have been discussed and resolved by the Incident Commander or the Unified Commanders. A major criticism of planning meetings is that they tend to drag on and consume valuable time. Some things that may help keep the meeting to the point include:

- All participants should be prepared, and should have already done their homework on important issues.
- The meeting facilitator should keep the meeting on track to ensure that the meeting objectives are being met.
- Radios, cellular phones, and other interruptions should be kept to an absolute minimum.
- If Agency Representatives are present, they should be allowed to address issues from their agencies.

Use the various ICS forms to develop the Incident Action Plan.

The designers of the Incident Command System created several forms to aid in the development of the Incident Action Plan. It is not absolutely necessary that these specific forms be used, but the information listed on them should be included in your plan. When all attachments are included, the plan specifies the control objectives, tactics to meet the objectives, resources, organization, communications plan, medical plan, and other appropriate information for use in the tactical operations.

PLANNING MEETING CHECKLIST

Activity	Primary Responsibility
State Incident Objectives and brief group on policy issues.	Incident Commander
Give situation and resources briefing and conduct the planning meeting.	Planning Section Chief
Lead group in the development of the primary and alternative strategies to meet objectives.	Operations Section Chief with contributions from Planning and Logistics Section Chiefs
Designate Branch, Division, Group boundaries and functions as appropriate.	Operations Section Chief
Describe tactical operations and tactics.	Operations Section Chief
Make tactical resource assignments.	Operations Section Chief with contributions from Planning and Logistics Section Chiefs
Specify reporting locations and additional facilities needed.	Operations Section Chief with contributions from the Logistics Section Chiefs
Develop the resources, support, and overhead order.	Planning and Logistics Section Chief. Logistics will place the order.
Consider additional support requirements needed because of communications, traffic, safety, medical, etc.	Logistics Section Chief. Planning Section Chief will contribute.
Finalize, approve, and implement the plan.	Planning Section chief finalizes the plan. Incident Commander approves it, and General Staff implements the plan.

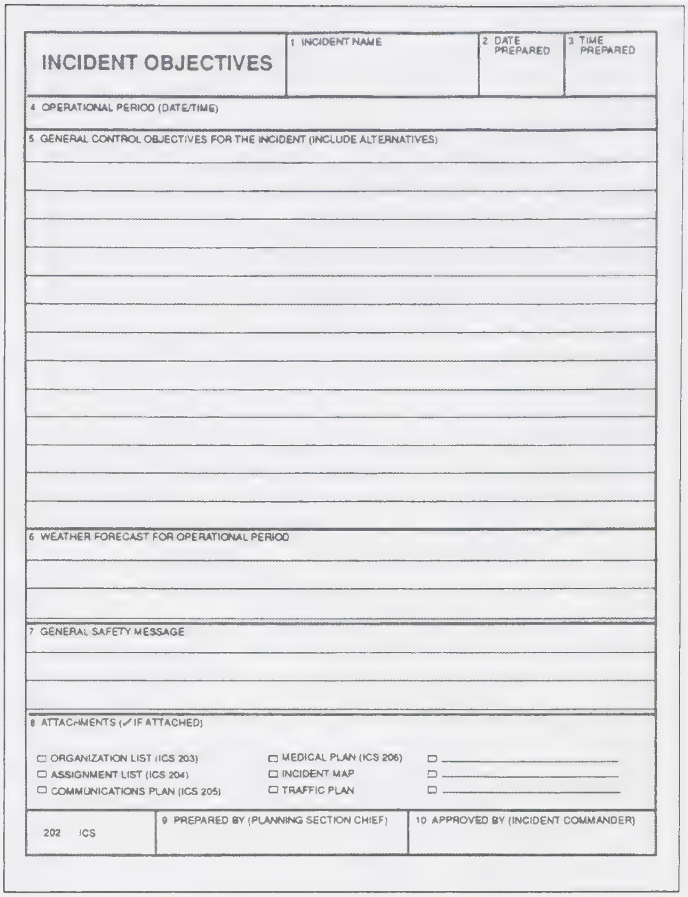
Figure 7.19 The Planning Section Chief facilitates planning meetings involving the General Staff.

Incident Objectives - The Incident Objectives Form (ICS Form 202) is the place where you list the objectives for the incident, present a weather synopsis, and a safety message (Figure 7.20). This form is usually used as the cover page of the plan. It is developed by the Incident Commander and the Command and General Staffs during the planning meeting.

Organization Assignment List (ICS Form 203) - This form describes the ICS organization that will be in place for each Operational Period, specifically, who is filling what positions (Figure 7.21). This list is developed by the Resources Unit under the direction of the Planning Section Chief.

Assignment List (ICS Form 204) - This form lists the specific resources that will be assigned to a division or group. It gives some detail about the resources assigned, outlines their strategy and tactics, and identifies the specific command and tactical radio frequencies to be used. This document is prepared by the Resources Unit which summarizes information from various members of the General Staff (Figure 7.22).

Incident Radio Communications Plan (ICS Form 205) - The Radio Communications Plan provides one location to summarize all radio frequency assignments for each operational period (Figure 7.23). This plan is prepared by the Communications Unit Leader and reviewed by the Planning Section Chief.



INCIDENT OBJECTIVES	1 INCIDENT NAME	2 DATE PREPARED	3 TIME PREPARED

4 OPERATIONAL PERIOD (DATE/TIME)

5 GENERAL CONTROL OBJECTIVES FOR THE INCIDENT (INCLUDE ALTERNATIVES)

6 WEATHER FORECAST FOR OPERATIONAL PERIOD

7 GENERAL SAFETY MESSAGE

8 ATTACHMENTS (✓ IF ATTACHED)

☐ ORGANIZATION LIST (ICS 203)	☐ MEDICAL PLAN (ICS 206)	☐ ________
☐ ASSIGNMENT LIST (ICS 204)	☐ INCIDENT MAP	☐ ________
☐ COMMUNICATIONS PLAN (ICS 205)	☐ TRAFFIC PLAN	☐ ________

202 ICS	9 PREPARED BY (PLANNING SECTION CHIEF)	10 APPROVED BY (INCIDENT COMMANDER)

Figure 7.20 Incident Objectives Form (ICS Form 202) - Use this form to outline the objectives for the incident, to summarize weather and safety points, and to indicate various attachments.

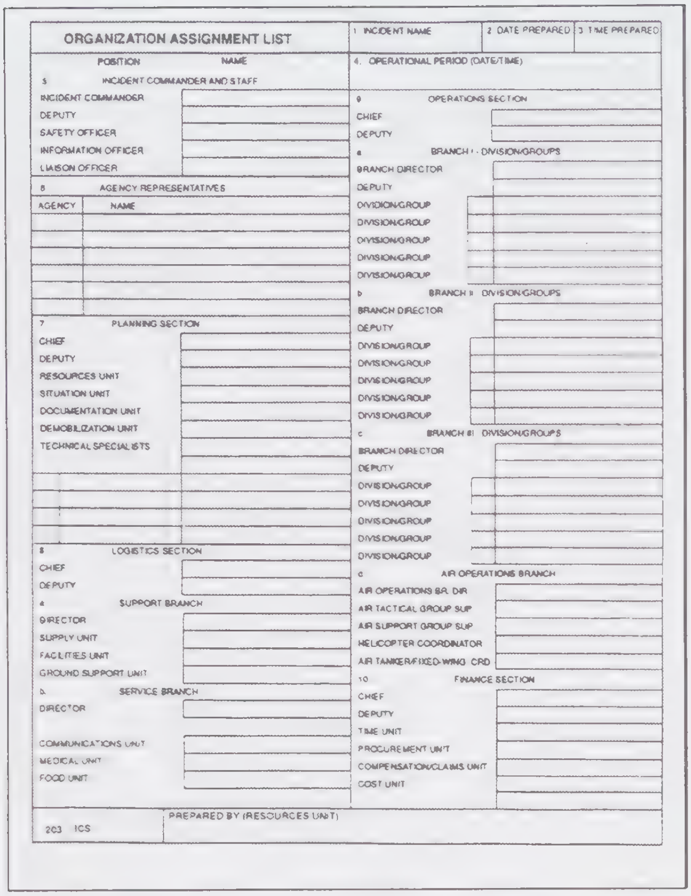
Medical Plan (ICS Form 206) - This document provides information on incident medical aid stations, transportation services, hospitals, and medical emergency procedures. It is prepared by the Medical Unit Leader and reviewed by the Safety Officer (Figure 7.24).

Other documents that are frequently attached to the Incident Action Plan include:

- Maps (especially topographic and road/street).
- Spot weather forecasts.
- Traffic Plans.
- Layout of Incident Base.

Once the Incident Action Plan is complete and approved for use by the Incident Commander, copies are provided to each Unit

On-shift operational personnel need to provide information to Planning on what resources and actions will be needed during the next operational period.



ORGANIZATION ASSIGNMENT LIST

1 INCIDENT NAME
2 DATE PREPARED
3 TIME PREPARED
4. OPERATIONAL PERIOD (DATE/TIME)

POSITION NAME

5 INCIDENT COMMANDER AND STAFF
INCIDENT COMMANDER
DEPUTY
SAFETY OFFICER
INFORMATION OFFICER
LIAISON OFFICER

6 AGENCY REPRESENTATIVES
AGENCY NAME

7 PLANNING SECTION
CHIEF
DEPUTY
RESOURCES UNIT
SITUATION UNIT
DOCUMENTATION UNIT
DEMOBILIZATION UNIT
TECHNICAL SPECIALISTS

8 LOGISTICS SECTION
CHIEF
DEPUTY
a SUPPORT BRANCH
DIRECTOR
SUPPLY UNIT
FACILITIES UNIT
GROUND SUPPORT UNIT
b SERVICE BRANCH
DIRECTOR
COMMUNICATIONS UNIT
MEDICAL UNIT
FOOD UNIT

9 OPERATIONS SECTION
CHIEF
DEPUTY
a BRANCH I - DIVISION/GROUPS
BRANCH DIRECTOR
DEPUTY
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
b BRANCH II DIVISION/GROUPS
BRANCH DIRECTOR
DEPUTY
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
c BRANCH III DIVISION/GROUPS
BRANCH DIRECTOR
DEPUTY
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
DIVISION/GROUP
d AIR OPERATIONS BRANCH
AIR OPERATIONS BR. DIR
AIR TACTICAL GROUP SUP
AIR SUPPORT GROUP SUP
HELICOPTER COORDINATOR
AIR TANKER/FIXED-WING CRD

10 FINANCE SECTION
CHIEF
DEPUTY
TIME UNIT
PROCUREMENT UNIT
COMPENSATION/CLAIMS UNIT
COST UNIT

203 ICS
PREPARED BY (RESOURCES UNIT)

Figure 7.21 Organization Assignment List (ICS 203) describes the ICS organization that will be in place for each Operational Period.

Leader in the organization. Unless modified by changing conditions, the plan will guide field operations for the period covered by the plan. If conditions change, the Incident Commander (working with the members of the General Staff) can modify the plan.

The development of the Incident Action Plan for the next operational period is the responsibility of "on-shift" personnel. In other words, most of the planning for any operational period should already be completed when the new shift comes on duty so that they don't have any unnecessary delays in accomplishing their objectives. They can get straight to work, adjusting the plan only if needed.

Resource Management

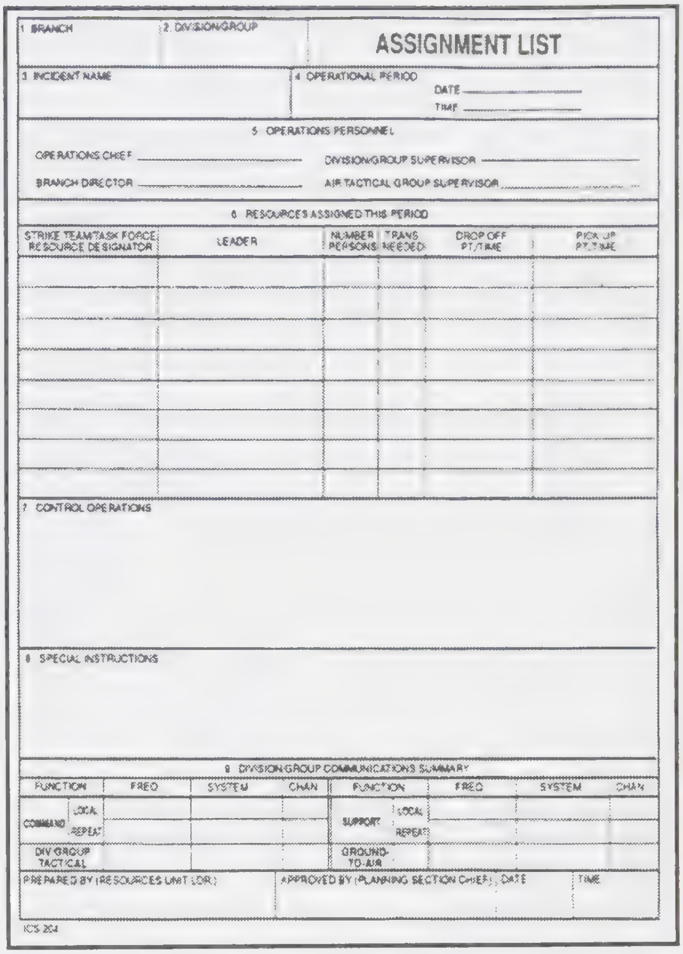
Resources are defined as any person, crew, team, piece of equipment, or grouping of people and/or equipment that is needed or used to abate an incident. This includes fire engines, bulldozers, hotshot crews, aircraft, division/group supervisors, etc. There are three general types of resources managed under ICS:

- **Single Resources** - A single resource is one person, one engine, or one of something else.
- **Task Forces** - A Task Force is a combination of single resources with common communications and a leader. A Task Force is assembled for a particular tactical need. This grouping can either be predetermined or formed at the incident.
- **Strike Teams** - A Strike Team is a combination of a **designated number of the same kind and type of resources** with common communications and a leader.

Order only the resources you need. Don't order a strike team of five engines if you only need three.

You would use a Task Force or Strike Team to increase the effectiveness of the resources (pre-designated teams work better together), reduce the span of control (the team leader answers for the team), and reduce communications traffic (each team has a common communications capability).

Originally, the development of Strike Teams was to facilitate ordering fire suppression resources, be it pumping capacity or line construction potential. It was also hoped that it would cut down on the information needed to be passed on through the dispatch or logistics channels. But, it has turned out to be a simple way to order five engines with a leader, even if you don't need five engines. If the Strike Team concept is misused, it puts an unnecessary drain on the resource pool. More and more agencies are now stressing the ordering of single resources. If you need three engines, that is what you order; if you need a leader, that is what you order. Remember to tailor your resource orders to your actual needs; keep it simple!



1 BRANCH

2. DIVISION/GROUP

ASSIGNMENT LIST

3 INCIDENT NAME

4 OPERATIONAL PERIOD
DATE ____________
TIME ____________

5 OPERATIONS PERSONNEL

OPERATIONS CHIEF ____________ DIVISION/GROUP SUPERVISOR ____________
BRANCH DIRECTOR ____________ AIR TACTICAL GROUP SUPERVISOR ____________

6 RESOURCES ASSIGNED THIS PERIOD

STRIKE TEAM/TASK FORCE/ RESOURCE DESIGNATOR	LEADER	NUMBER PERSONS	TRANS NEEDED	DROP OFF PT./TIME	PICK UP PT./TIME

7 CONTROL OPERATIONS

8 SPECIAL INSTRUCTIONS

9 DIVISION/GROUP COMMUNICATIONS SUMMARY

FUNCTION		FREQ	SYSTEM	CHAN	FUNCTION		FREQ	SYSTEM	CHAN
COMMAND	LOCAL				SUPPORT	LOCAL			
	REPEAT					REPEAT			
DIV/GROUP TACTICAL					GROUND-TO-AIR				

PREPARED BY (RESOURCES UNIT LDR.)	APPROVED BY (PLANNING SECTION CHIEF)	DATE	TIME

ICS 204

Figure 7.22 Assignment List (ICS Form 204) outlines the specific assignment information for each division or group. It also specifies the strategy and tactics to be used and the various radio frequencies that are assigned.

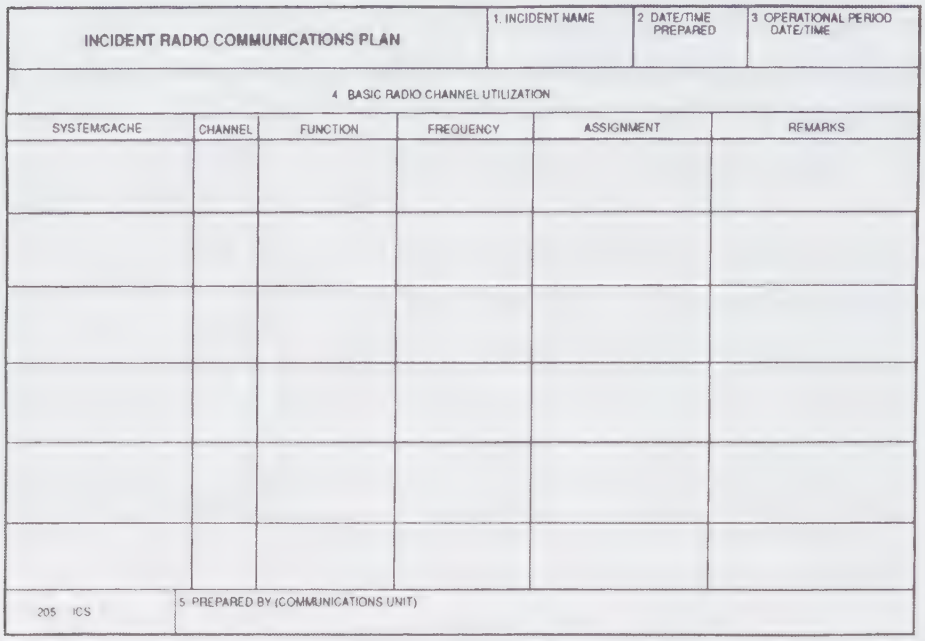
The advantages of using Task Forces or Strike Teams include:

- Enabling you to use resources more effectively. You can give the team leader an assignment and they can carry it out. You don't have to waste time instructing each resource on what you want or need.
- Providing an effective way of quickly ordering resources.
- Reducing radio traffic by channeling communications through a team leader, rather than to each single resource.
- Increasing the ability to expand the organization for large incident operations while maintaining good span of control.
- Providing close resource control and accountability.

The maintenance of accurate status is important to the smooth operations of the incident.

Each resource or team will be in one of three status conditions, **assigned**, **available** or **out-of-service**:

- **Assigned** means that the resource is committed to its assigned task and is not available for another assignment. An engine pumping a hose lay is assigned.



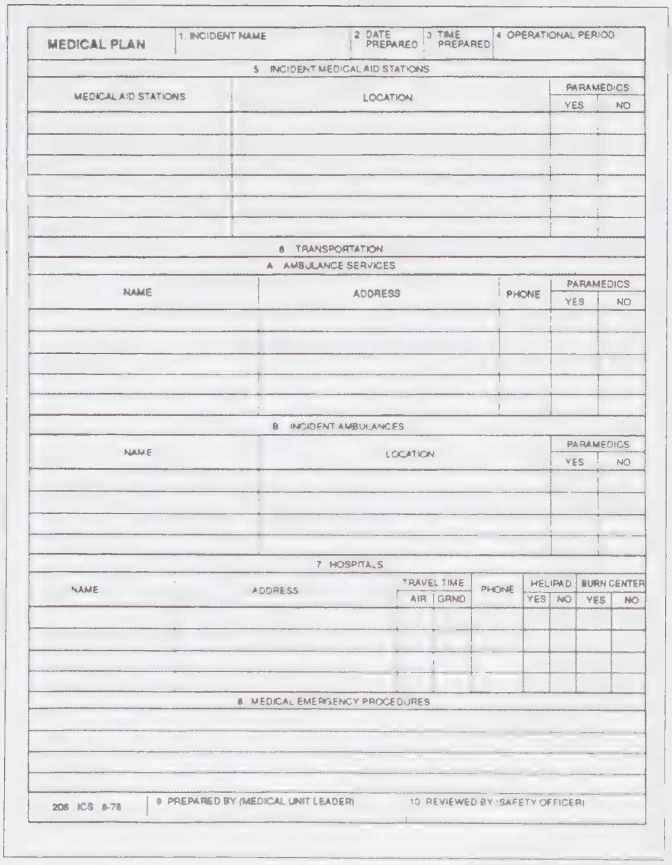
INCIDENT RADIO COMMUNICATIONS PLAN
1. INCIDENT NAME
2 DATE/TIME PREPARED
3 OPERATIONAL PERIOD DATE/TIME

4 BASIC RADIO CHANNEL UTILIZATION

SYSTEM/CACHE	CHANNEL	FUNCTION	FREQUENCY	ASSIGNMENT	REMARKS

205 ICS
5 PREPARED BY (COMMUNICATIONS UNIT)

Figure 7.23 Incident Radio Communications Plan (ICS Form 205) - outlines the use of all the radio frequencies assigned to the incident.



MEDICAL PLAN
1. INCIDENT NAME
2 DATE PREPARED
3 TIME PREPARED
4 OPERATIONAL PERIOD

5 INCIDENT MEDICAL AID STATIONS

MEDICAL AID STATIONS	LOCATION	PARAMEDICS YES	PARAMEDICS NO

6 TRANSPORTATION

A AMBULANCE SERVICES

NAME	ADDRESS	PHONE	PARAMEDICS YES	PARAMEDICS NO

B INCIDENT AMBULANCES

NAME	LOCATION	PARAMEDICS YES	PARAMEDICS NO

7 HOSPITALS

NAME	ADDRESS	TRAVEL TIME AIR	TRAVEL TIME GRND	PHONE	HELIPAD YES	HELIPAD NO	BURN CENTER YES	BURN CENTER NO

8 MEDICAL EMERGENCY PROCEDURES

206 ICS 8-78
9 PREPARED BY (MEDICAL UNIT LEADER)
10 REVIEWED BY (SAFETY OFFICER)

Figure 7.24 Medical Plan (ICS Form 206) - provides the information needed to respond to any medical emergency related to the incident.

- **Available** means a resource is assigned to an incident and is available for an assignment. An engine parked in staging is available.
- **Out-of-Service** means the resource is assigned to an incident but is neither assigned, nor available for assignment to a task. The engine may be "mechanically challenged," there may be insufficient personnel to operate the equipment, or the crew may be off-shift and resting. In some cases, a piece of apparatus may be out-of-service because it cannot be used at night (helicopters and airtankers) or for fiscal reasons, such as no authorized overtime.

The maintenance of accurate status is important to the smooth functioning of any emergency operation. Under ICS, the only people who can change the status of a resource are those that control it. It could be an engine company captain saying the engine has a flat tire, or the Operations Section Chief moving an engine from the fireline so the crew can rest. The person making the status change must ensure that the change reaches the Resource

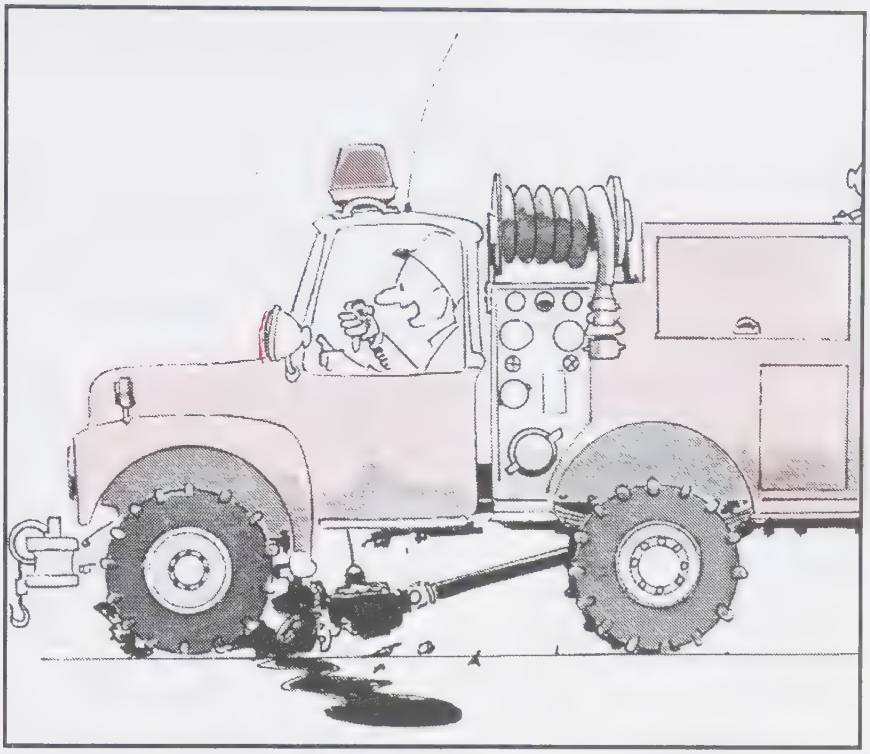


Figure 7.25 This fire officer's engine is "mechanically challenged," and he is reporting the fact to the Task Force Leader and the Resources Unit.

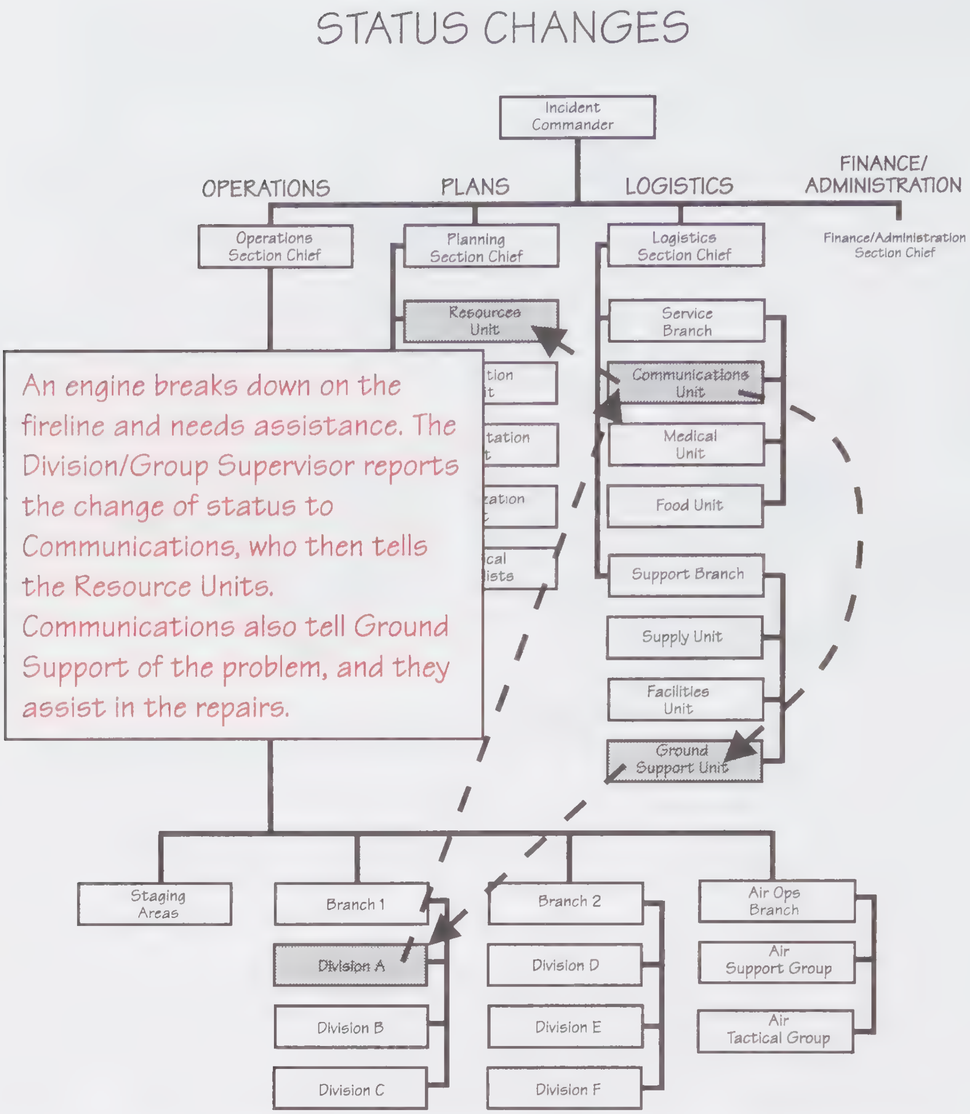
Unit (the keeper of equipment status on major incidents) or whoever is keeping this information (Figure 7.25). It is the responsibility of each Division/Group Supervisor (or Branch Director or Operations Section Chief) to keep the Resources Unit informed of status changes for units assigned to field operations (Figure 7.26).

To properly manage an emergency, you need to have a functioning organization.

Developing the Organization

The development of an organization that will be able to deal with the emergency at hand should start during training and within your daily operations. Remember that for ICS to be effective, it should be used all of the time. Also remember that ICS only requires one position to be filled, so as soon as the first firefighter arrives at a fire, he/she is the Incident Commander and responsible for everything that goes with it (Figure 7.27).

The location of the ICP should be known by everyone on the incident and by dispatch.


STATUS CHANGES

Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Resources Unit
Service Branch
Communications Unit
Medical Unit
Food Unit
Support Branch
Supply Unit
Facilities Unit
Ground Support Unit
Staging Areas
Branch 1
Division A
Division B
Division C
Branch 2
Division D
Division E
Division F
Air Ops Branch
Air Support Group
Air Tactical Group

An engine breaks down on the fireline and needs assistance. The Division/Group Supervisor reports the change of status to Communications, who then tells the Resource Units. Communications also tell Ground Support of the problem, and they assist in the repairs.

Figure 7.26 Status changes should reported to the Resource Unit. It is the responsibility of each Division/Group Supervisor to ensure this information reaches the Resource Unit.

There are no hard and fast rules for when or how to begin expanding the organization. Many incidents will never require the activation of Planning, Logistics, or Finance/Administration.

All incoming firefighting resources should report to a staging area.

There are a few things that you should do up front to make it easier on all personnel in the event that the initial suppression actions are not successful. These are:

Incident Command Post (ICP) - Pick a spot where you can see the incident and which is easy for people to find. Tell dispatch the location so that it can be broadcast to all those responding. The ICP may be your vehicle, a trailer, a tent, a school, under a tree, or any location suitable to accommodate the function at this stage of the emergency. Normally, the ICP will not be moved, but it can be as an incident develops.

Staging Area - By establishing a Staging Area and announcing its location, you provide one location for all responding resources to report to. In this way, you don't have to "busy" the radio communications system with reporting instructions; everyone knows where to report. This also aids in check-in, which is vital if you ever want to know who is on the fire.

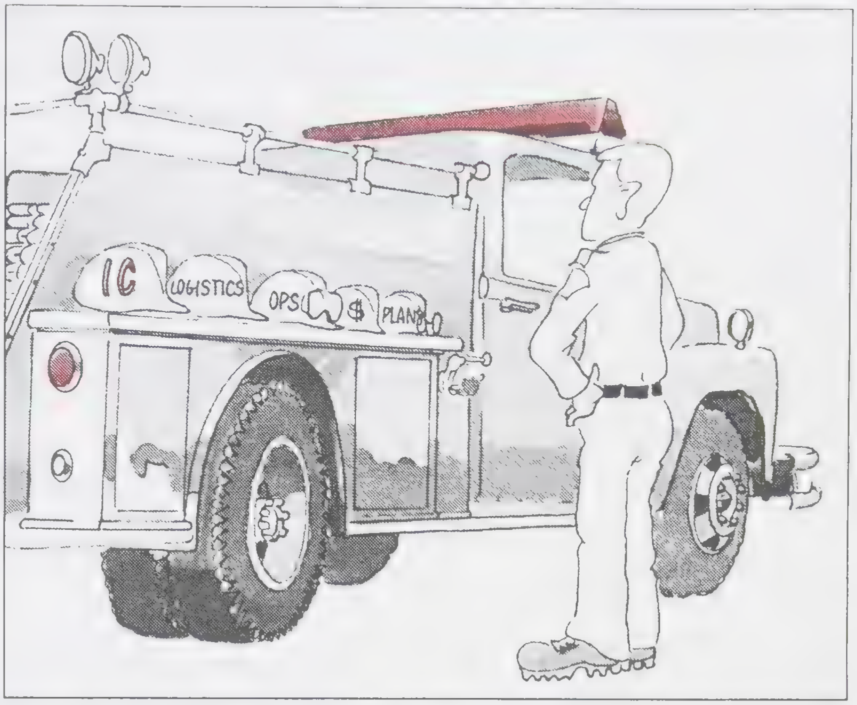


Figure 7.27 The first firefighter at an incident is the Incident Commander and must wear many hats until replaced by a ranking or more experienced person, or until certain functions or responsibilities are delegated.

Divisions - If the incident has any chance of expanding, think "Division." This will aid in your span of control and dispel any notion that ICS is not going to be used. It also sets the stage for easy expansion of the organization.

It is better to overestimate the need for an organization than to underestimate it. It is always easy to "turn around" or release unused resources. The next stage in development would be to fill certain Command and General Staff functions (like Information and Operations) and part of the Planning staff (like Resources and Situation Status Unit Leaders).

The transfer of command should not be a big deal. It should be simple and "transparent."

Transfer of Incident Command

As an incident grows, it may be necessary to change the Incident Commander. This transfer of control is made easy by the use of ICS. The transfer of command may be triggered by the arrival of a senior officer or more qualified person who elects/is appointed to take control, or by the transfer of command to an Incident Management Team. Although command can simply change, and a new "voice" answers to the title of Incident Commander, it is best if the change is announced on the radio. This is the only way to ensure that command has actually transferred. If there has not been an announcement, then command has not been transferred.

The decision to transfer command should be based on the complexity of the incident and the qualifications, expertise, or experience of those available. The Incident Commander who is being replaced should provide the following information to the new IC:

- Status of the incident and a little history of how it developed.
- Objectives and priorities that have been developed and why they were selected.
- Current organizational structure.
- Resources presently assigned, en route, or on order.
- Facilities established and their locations.
- Communications Plan.
- Prognosis, concerns, and other related issues.

Small fires can be major events.

The Incident Briefing form, ICS 201, is excellent as a script for this briefing.

Major Incident Management

Every so often, a fire or series of fires grows large enough to be called a major incident. You might think that there is an acreage threshold that turns a fire into a major event. However, acreage is only one factor that needs to be considered. The Tunnel Fire in Oakland was only a little over 1,500 acres—a relatively small fire in terms of acres. What turns a fire into a major event is how the fire itself impacts people, property, or resources.

Unified Command is one of the most important features of ICS.

When a situation turns bad, several other things occur. More than one agency or jurisdiction becomes involved. The number of resources assigned usually increases, or resources become scarce and priorities have to be set. The Incident Command System also addresses these concerns with Unified Command, Complexes, Area Command, and MultiAgency Coordination.

Unified Command

Unified Command allows all agencies which have jurisdictional or functional responsibility for part of the incident to jointly develop a common set of incident objectives and strategies. This can be accomplished without the initial responding agency losing or giving up its authority, responsibility, or accountability. Unified Command is an important feature of ICS. It allows agencies having a legitimate responsibility at an incident to be part of the command structure. Specifically, Unified Command provides the following advantages:

- The incident is managed under a single set of objectives, coordinated in the Incident Action Plan.
- There is one Operations Section Chief who is responsible for implementing the plan.
- There is one Incident Command Post.
- All agencies with responsibility for the incident have an understanding of one another's priorities and restrictions.
- No agency's authority or legal requirements will be compromised or neglected.
- The combined efforts of all agencies are optimized as they perform their respective assignments under a single plan.
- Duplication of effort is reduced or eliminated, thus reducing cost and chances for frustration and conflict.

The command structure should accommodate all jurisdictions that have responsibility for part of the incident.

The great thing about the ICS Unified Command setup is that it will accommodate almost any jurisdictional arrangement.

UNIFIED COMMAND INVOLVING SEVERAL JURISDICTIONS

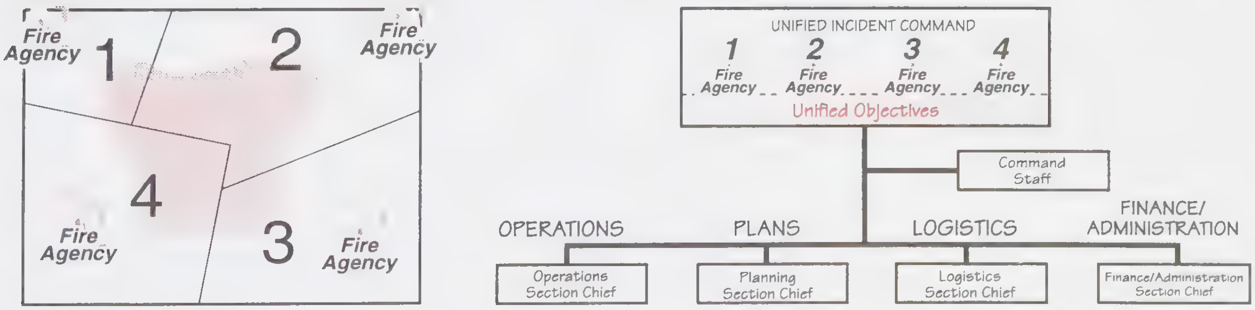

Fire Agency
1
2
Fire Agency
4
Fire Agency
3
Fire Agency
UNIFIED INCIDENT COMMAND
1 Fire Agency
2 Fire Agency
3 Fire Agency
4 Fire Agency
Unified Objectives
Command Staff
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.28 This Unified Command structure is one of the simplest in that it involves several fire service entities fighting a fire that is burning in several jurisdictions. Each of the fire departments may be from differing jurisdictions, but they are from one kind of operation (the fire service), and there is one common "enemy" (the fire).

UNIFIED COMMAND INVOLVING SEVERAL AGENCIES IN ONE JURISDICTION

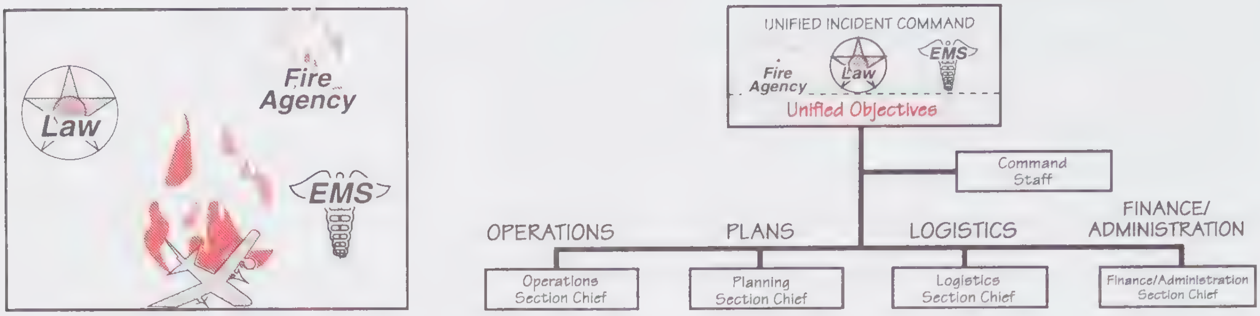

Law
Fire Agency
EMS
UNIFIED INCIDENT COMMAND
Fire Agency
Law
EMS
Unified Objectives
Command Staff
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.29 The situation is a little more complicated when several different agencies are involved. Each of these entities have different "enemies." In a riot situation, the police have the rioters, the fire department has to deal with the fires that are started by the rioters, and the emergency medical agencies have to deal with the injured (which may be rioters, the general public, or police and firefighting personnel).

UNIFIED COMMAND INVOLVING SEVERAL AGENCIES IN SEVERAL JURISDICTIONS

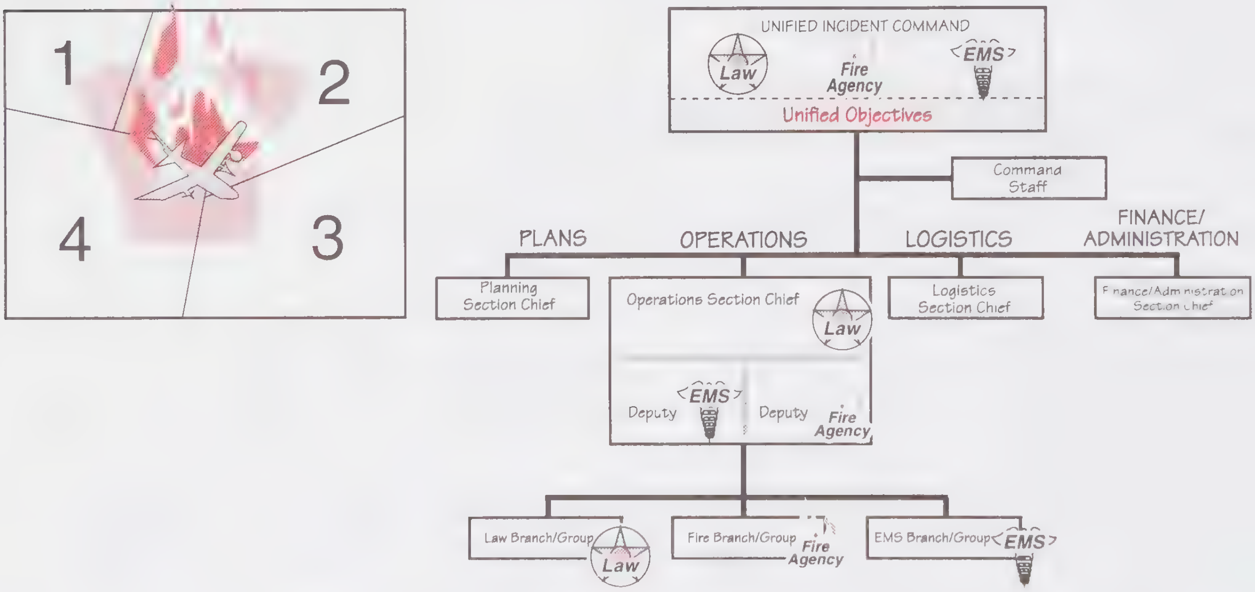

1
2
3
4
UNIFIED INCIDENT COMMAND
Law
Fire Agency
EMS
Unified Objectives
Command Staff
PLANS
OPERATIONS
LOGISTICS
FINANCE/ ADMINISTRATION
Planning Section Chief
Operations Section Chief
Law
Logistics Section Chief
Finance/Administration Section Chief
Deputy
EMS
Deputy
Fire Agency
Law Branch/Group
Law
Fire Branch/Group
Fire Agency
EMS Branch/Group
EMS

Figure 7.30 The most complicated Unified Command structure is one where there are several agencies and jurisdictions involved. Then, if you also have several levels of government (local, state, and federal), patience and the system are really tested. In this example, note how deputies and groups allow more involvement of the various jurisdictions and agencies.

The simplest form is when there are several fire agencies fighting a fire that crosses jurisdictional boundaries (Figure 7.28). Things get a little more complicated when the incident involves several different agencies (police, fire, medical, etc.) in one jurisdiction (Figure 7.29). The most complicated form is when the incident involves several different agencies from several different jurisdictions (Figure 7.30).

Under a Unified Command structure, the various jurisdictions/agencies are blended together into an integrated team. The resulting organization may be a mix of personnel from several agencies, each performing functions as appropriate and working toward a common set of objectives.

The proper mix of participants will depend on:

- The **location of the incident**, which often determines the jurisdictions that will be involved.
- The **kind of incident**, which dictates the agencies that will be involved.

One of the bigger problems in a major incident is who pays.

One of the biggest hurdles in any multi-jurisdictional incident is determining who is going to pay for what. Smaller jurisdictions don't usually budget for major disasters. Larger state or federal agencies usually have emergency funds they can use but, in a lot of cases, the largest cost item (structure protection) really is not their responsibility. So the early development of a cost share plan is very important.

Another issue that will take some coordination is the establishment of a plan regarding who will order what resources through what channels. If everyone involved orders separately, it may facilitate payment (you ordered it, you pay for it), but it can lead to some costly duplication. Also, it is very difficult to order scarce resources, like airtankers and helicopters, if everyone is doing their own thing.

To eliminate duplication in orders, designate a single ordering point.

Ordering can be streamlined in two ways: designating a single ordering point (all orders for the incident go to one dispatch center for processing), or giving the Logistics Section direction on which kinds of resources will be ordered through which dispatch office. The issue of who pays is still there, but the main thing is that the needed resources are ordered and the orders get processed.

Some of the other issues the Unified Command will have to deal with are:

- Selection of an Operations Section Chief that they all feel comfortable with. This person should be highly qualified and experienced. There must be full agreement with the choice, and he/she must be given full authority to implement the plan.
- Designation of one spokesperson for Unified Command.
- Designation of the lead Information Officer.

Establish a complex when several fires can be effectively managed by one ICS command structure.

Complexes

The term "complex" is used to describe a situation when two or more individual incidents located in the same general area are managed by a single incident management team. When a complex is established, the individual incidents (fires) become branches within the Operations Section of the ICS organization (Figure 7.31). If one of the fires within a complex grows too large, it may be wise to establish a separate ICS organization to manage it.

Complexes are most often established after a series of fires started by lightning. But that doesn't preclude the use of a complex in response to an earthquake, tornado, flood, or any event where several separate but common events are within close proximity. A complex can also be established if a new fire starts near an existing fire, and the new fire is managed by the existing ICS organization.

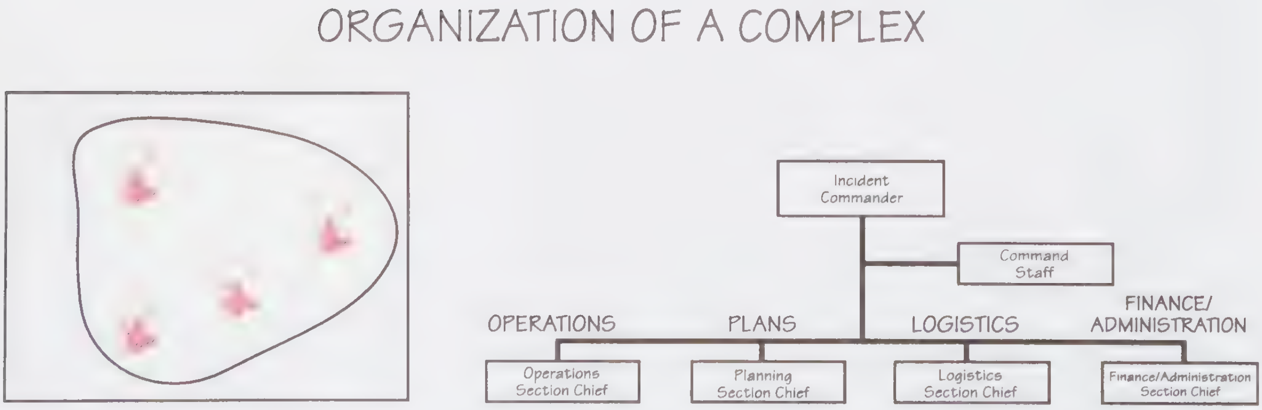

ORGANIZATION OF A COMPLEX
Incident Commander
Command Staff
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.31 The fires within this complex become branches within the ICS organization.

Expanding the ICS Organization

There may be times when an incident grows so large that you may have to divide it into two or more separate incidents, each managed by separate organizations (Figure 7.32). This could happen if a flood covers several counties or states. If possible, retain a Unified Command structure. If that isn't possible, utilize an area command or establish a MultiAgency Coordination system. Both are discussed later in this chapter.

Use the ICS system to tailor the organization to match the complexity of the incident.

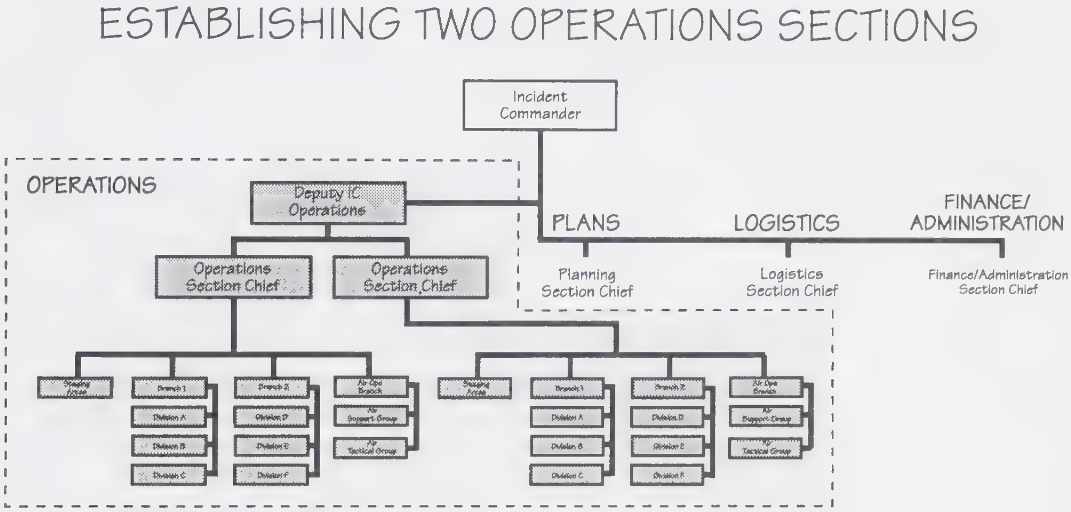

ESTABLISHING TWO OPERATIONS SECTIONS
Incident Commander
OPERATIONS
Deputy IC Operations
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Staging Areas
Branch 1
Division A
Division B
Division C
Branch 2
Division D
Division E
Division F
Air Ops Branch
Air Support Group
Air Tactical Group
Staging Areas
Branch 1
Division A
Division B
Division C
Branch 2
Division D
Division E
Division F
Air Ops Branch
Air Support Group
Air Tactical Group

Figure 7.32 If the incident is of such a size that the Operations Section needs to be divided, establish the second Operations Section Chief and a Deputy Incident Commander-Operations position.

ICS is also designed to allow for multiple sections (for example, two Operations or Logistics Sections), if the incident is so large that the span of control is excessive. It is recommended that if two or more sections are overtaxed, the incident should be divided into two separate incidents.

Another option is to conduct planning at the branch level, developing an Incident Action Plan for each branch. If it becomes necessary to do this, ensure that the overall objectives for the total incident are followed.

An Area Command is used to manage several major fires in a general area.

Area Command

An Area Command is established to oversee the management of several incidents in the same area, usually of the same type (each being managed by a separate ICS organization), or to

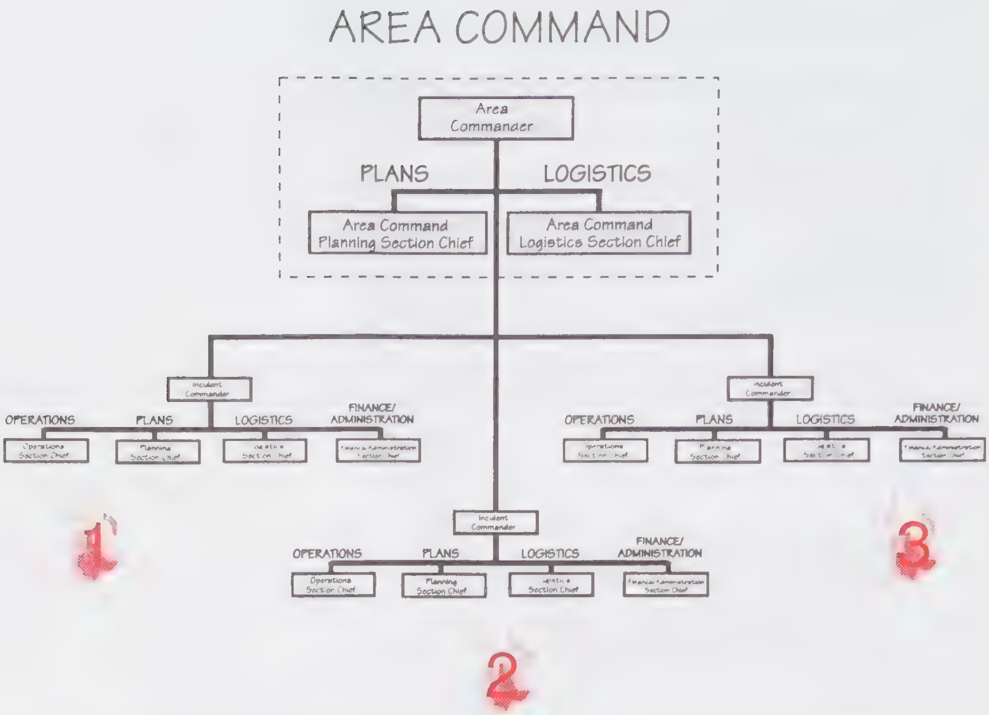

AREA COMMAND
Area Commander
PLANS
LOGISTICS
Area Command Planning Section Chief
Area Command Logistics Section Chief
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Section Chief
Section Chief
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Section Chief
Section Chief
Section Chief
Finance Administration Section Chief
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Section Chief
Finance/Administration Section Chief
1
2
3

Figure 7.33 Area Command is established to manage several large fires.

manage a very large incident when several management teams are in place to direct it. If several jurisdictions are involved, a Unified Area Command organization should be established (Figure 7.33).

The responsibilities of an Area Command organization are:

- Set overall agency incident-related priorities.
- Allocate critical resources based on these priorities.
- Ensure that the various incidents are properly managed.
- Ensure that the incidents' objectives are met and do not conflict with each other or with agency policy.

The power of MAC lays in the authority of the individual members.

MultiAgency Coordination

The concept of MultiAgency Coordination (MAC) is quite simple. It is when the leadership of different agencies or jurisdictions meet to discuss and set common goals with regards to the management of emergency operations or any other topic. The term "coordination" is key to understanding the authority of a MAC. It is not a "command," thus does not have the authority attributed to that term. The power of a MAC is vested in the authority of the individuals who participate in the coordination meeting (Figure 7.34).

The key to the success of a MAC is the willingness of the participants to cooperate and compromise in the development of a common goal, and that the individual members have the authority to follow through on the decision of the group.

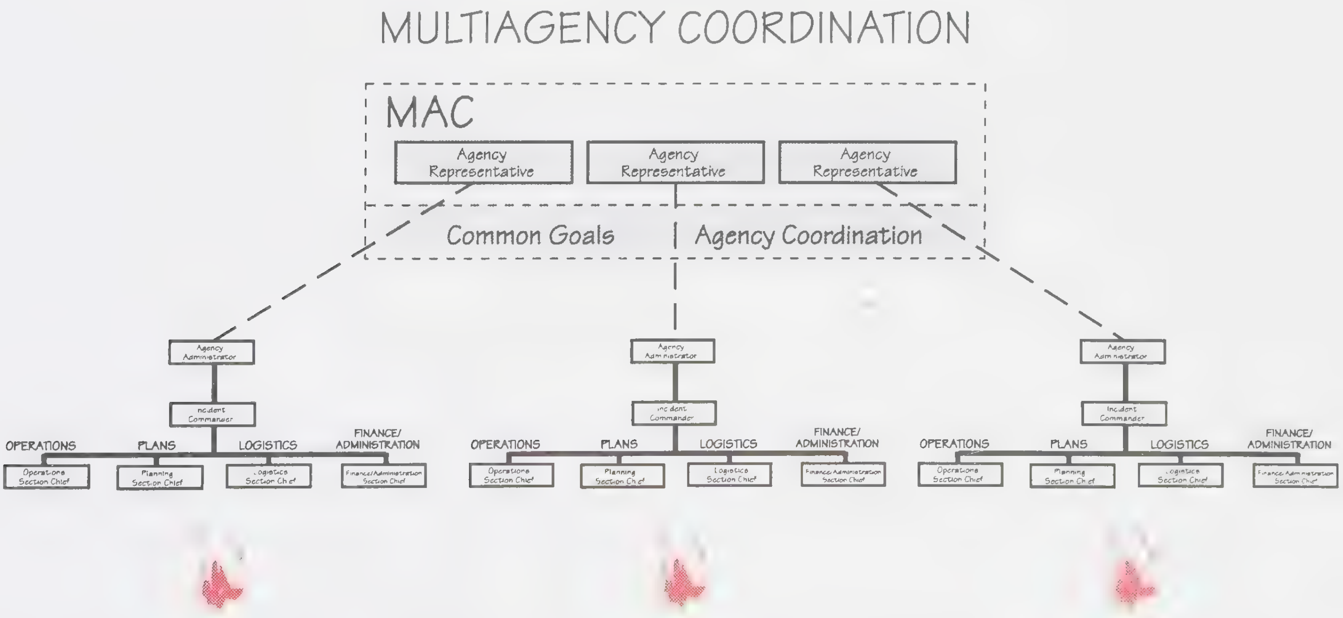
A MAC will be successful if the members are willing to participate, cooperate and compromise, and they are able to carry out the decisions.

MultiAgency Coordination is not new. In its own way, the United Nations is a MAC. One example of a MAC specific to wildland firefighting is the National Wildfire Coordinating Group, which includes representatives from various federal wildland fire agencies and state forestry organizations, and which provides overall nationwide coordination. There are MACs at the state and local levels that coordinate disaster planning and responses.

A MAC functions outside the jurisdiction's line of authority or command and control system. The MAC does not communicate directly with Incident Commanders. However, it may communicate to the Incident Commanders through other agency representatives.

Some of the functions of a MAC are:

- Development of priorities to be used in filling orders. This is especially important when resources are limited or scarce.


MULTIAGENCY COORDINATION
MAC
Agency Representative
Agency Representative
Agency Representative
Common Goals
Agency Coordination
Agency Administrator
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief
Agency Administrator
Incident Commander
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Operations Section Chief
Planning Section Chief
Logistics Section Chief
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Agency Administrator
Incident Commander
OPERATIONS
PLANS
LOGISTICS
FINANCE/ ADMINISTRATION
Operations Section Chief
Planning Section Chief
Logistics Section Chief
Finance/Administration Section Chief

Figure 7.34 MultiAgency Coordination (MAC) is when representatives from different agencies and jurisdictions meet to develop a common goal.

This includes the development of overall situation assessment. Normally, priorities are determined by the threat to life, property, and natural resources.
- Resource allocation. There may be times that resources are moved from one incident to another.
- Coordination of media information.
- Providing a common point for agency leadership contact. MAC can also provide assistance and information services to interested elected and appointed officials.
- Resolution of conflicts between different agencies.

Trust is important to the success of a MAC.

As noted, a MAC will not be able to function if the players don't have the authority to follow through with the collective decision or if there is a lack of trust between the members. Trust is important, and trust will not be developed if the individuals are strangers. MACs should be established and functioning well before a disaster.

The difference between a MAC and Unified Command or Area Command is that MAC is a coordination function, and the two Commands, have direct line authority.

The Incident Command System was developed to be used when very different agencies are involved in an incident. The next chapter outlines the various agencies that may be involved in wildland firefighting.

8

Jurisdictional Coordination

The purpose of this chapter is to give the fire officer a look at the individual "trees" in that forest called "the fire service." You will see that the basic authorities for some of these agencies may be very different, may overlap, and may sometimes be in conflict.

Most of the time when we begin our careers in the fire service, we are so tied to our own agency that we don't realize the actual extent of the fire service. There are thousands of individual fire departments or firefighting agencies in this nation. Most of them are staffed entirely by volunteers, or by some combination of paid, paid-call, and volunteer firefighters.

Not all of these fire departments or agencies have wildland fire protection as their primary mission, but a majority are involved with a wildland fire on occasion. This involvement may be through assisting another local fire department, through a regional or state-level mutual aid system, or through assistance-by-hire agreements with various state or federal agencies.

Besides the thousands of firefighting agencies, there are private companies in the business of firefighting. There are also associations that focus on wildland firefighting, as well as federal, state, and local fire or emergency coordination centers.

Federal Agencies

Organized wildland fire protection has its roots in the United States with the establishment of the Forest Service in the early

In this chapter, you'll

- *Learn how complicated the wildland fire protection system is.*
- *Learn about the wildland fire protection programs of various federal agencies.*
- *Learn how the National Fire Protection System can impact your day-to-day operations.*

1900s. Therefore, we will start with an overview of the Forest Service, followed by some of the other federal agencies that may impact you and your day-to-day operations.

Forest Service

The National Forest System was established in 1891 with the passage of the Forest Reserve Act. The Forest Service was established in 1905 during Theodore Roosevelt's presidency. The first chief of the service was Gifford Pinchot. It was the decision of Congress that the Forest Service be placed within the Department of Agriculture, since timber was considered a renewable resource, much like other agricultural crops. Up until recently, National Forest System lands were managed subject to multiple-use plans, under which recreation, timber harvesting, wildlife, and water quality protection were balanced. In recent years, the policy focus has been moving more and more towards preservation.

The Forest Service was established in 1905.

The Forest Service protects over 231 million acres of national forest and grasslands in the Nation: 160 million acres west of the Mississippi River, 47 million acres east of the Mississippi, and 24 million acres in Alaska. The vast majority of the land west of the Mississippi River and in Alaska was originally within the lands that the government owned, which was called the "public domain." The national forests located east of the Mississippi River have been purchased over the years. There are 155 national forests and 20 national grasslands in the service (Figure 8.1).

The Forest Service protects 231 million acres.

The Forest Service is designated by law to be the lead firefighting agency when a national disaster is declared and the Federal Emergency Disaster Plan is invoked. It is also the agency that coordinates forest management issues between the states and their State Foresters.

There are 155 national forests.

The Forest Service has an extensive fire protection system. It staffs hundreds of engine companies each fire season. It operates an extensive fleet of heavy airtankers, helicopters, and air-attack aircraft. It trains and utilizes highly skilled 20-person "hotshot crews" and smokejumpers. About 50% of the Forest Service's fire protection budget is allocated to the 18 national forests in California.

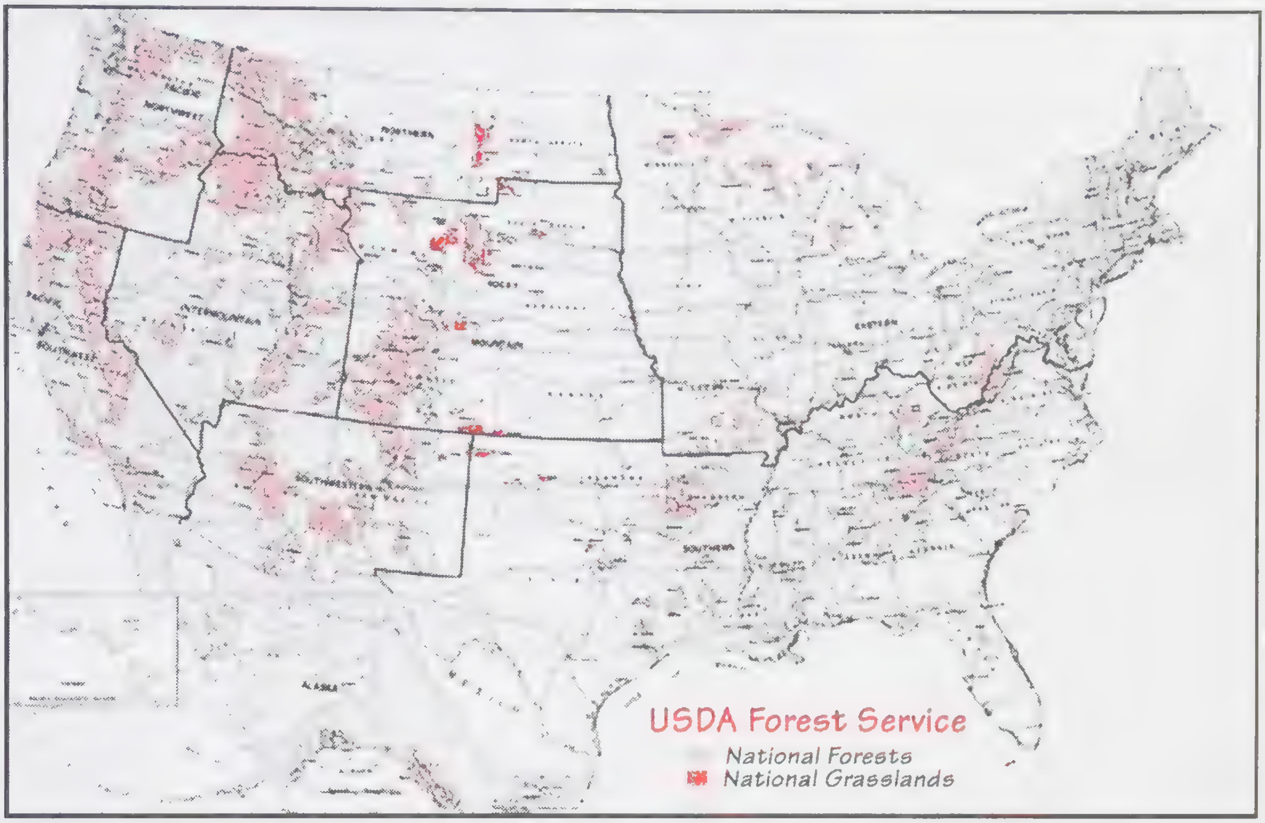


Figure 8.1 The Forest Service protects over 231 million acres, including 155 national forests and 20 national grasslands. The vast majority are in the western states.

Following the devastating fires in the Northern Rockies in 1910, which destroyed over 3 million acres in Idaho and Montana, the Forest Service adopted a philosophy of "outright prevention and suppression." It is said that the "fires of 1910 mesmerized and traumatized a long succession of Forest Service Chiefs..." Then in the late 40s, Smokey Bear entered the scene with his message: "Only you can prevent forest fires." Fire was bad; fire was evil.

Several things happened in the last twenty years to bring about a change in the history of the strong fire suppression policy. They were:

- A realization that the buildup of forest fuels and litter was the primary cause of devastating fires.
- The introduction of people and their homes into traditional wildland areas.
- The fire disasters of the late 80s and early 90s.

The vast majority of Forest Service protection is west of the Mississippi River.

The fires of 1910 set the stage for an all-out effort to suppress all fires.

- The 1988 fire season, in particular, the fires in Yellowstone National Park.

In 1994, the Forest Service began the development of a new fire policy to deal with the urban/wildland issue and the overall change in the Forest Service's management philosophy. The Forest Service drew criticism from several state and local agencies because the new policy was such a radical change. In 1996, this new Federal Wildland Fire Policy was adopted by the agencies of the Departments of Agriculture and Interior. The new policy is meant to guide and direct the actions of these agencies into the 21st century. It is important that you, as a fire officer, understand the rules and objectives of the federal wildland fire agencies. Some of the key elements of this new policy are:

In 1994 a new fire policy was adopted by the Forest Service.

- Protection of human life is reaffirmed as the first priority in wildland fire management. Property and natural/cultural resources jointly become the second priority, with protection decisions based on values to be safeguarded and other considerations. This is a change from the historic protection priorities where property is protected before natural/cultural resources.
- Wildland fire, as a critical natural process, must be reintroduced into the ecosystem.
- Where wildland fire cannot be safely reintroduced because of hazardous fuel buildups, some form of pretreatment must be considered, particularly in wildland/urban interface areas.
- All aspects of wildland fire management will be conducted with the involvement of all federal, state, and local partners; programs, activities, and processes will be compatible.
- The role of the federal agencies in the wildland/urban interface includes wildland firefighting, hazardous fuels reduction, cooperative prevention and education, and technical assistance. No one entity can resolve and manage all interface issues; it must be a cooperative effort. Ultimately, however, the primary responsibility rests at the state and local levels. (NOTE: This section of the federal firefighting policy is key; the federal agencies are willing to assist in the wildland/urban interface as long as they stay within their field of expertise: wildland firefighting.

In 1996, the federal agencies adopted a new wildland/urban policy.

They also state, rightfully so, that the wildland/urban interface problem is primarily a state and local government problem.)

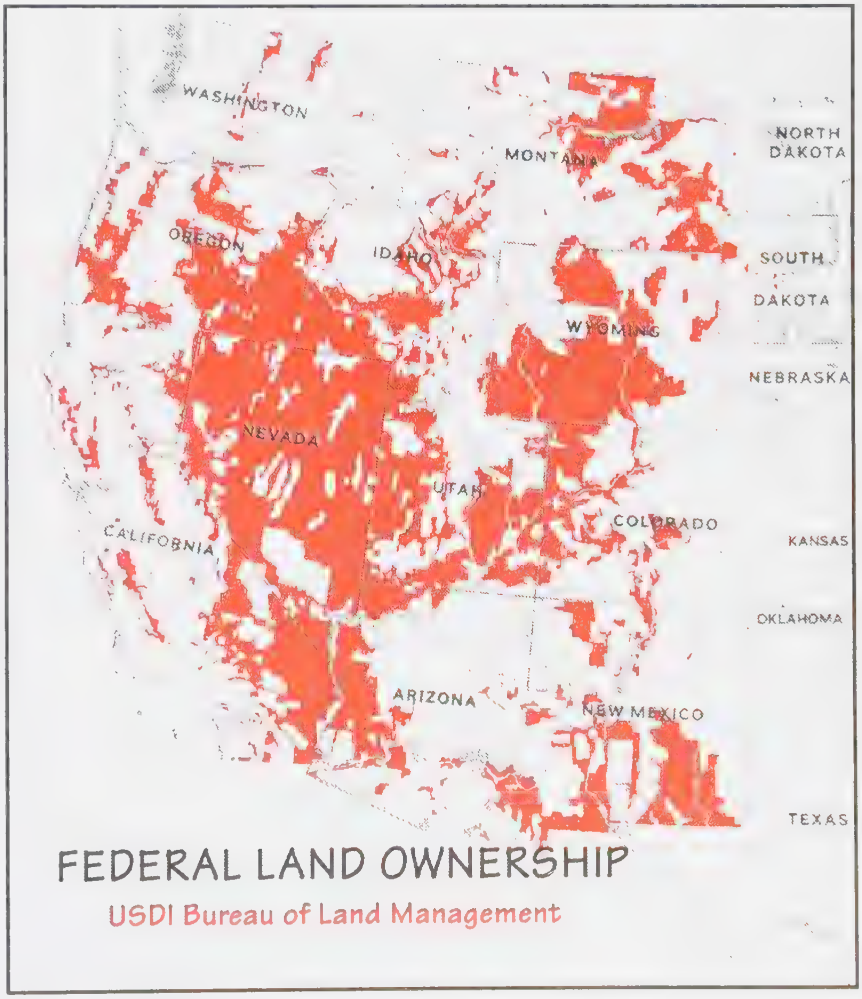
- Structural fire protection in the wildland/urban interface is *not* a federal fire problem.

Structure protection in the wildland/urban interface is not a federal responsibility.

If you work with a federal agency on a regular basis, meet with them and discuss how they interpret the fire policy, and how they will follow it during a fire fight. It is best to discuss the issues before the fire, rather than during or after it.

Bureau of Land Management

The Bureau of Land Management is an agency of the Department of the Interior. It is a relatively new agency, formed in 1946, when the General Land Office and the US Grazing Service were combined. The Bureau of Land Management protects about 270 million acres in the 12 western states. All of this land is part of the original 1.8 billion acres of "public domain" from which over a billion acres were transferred to private citizens, corporations, and the states. Millions of acres of "public domain" were set aside as national forests, national parks, game preserves, military facilities, and other public purposes. The remaining 270 million acres protected by the bureau is "the land that nobody wanted" (Figure 8.2).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FEDERAL LAND OWNERSHIP
USDI Bureau of Land Management

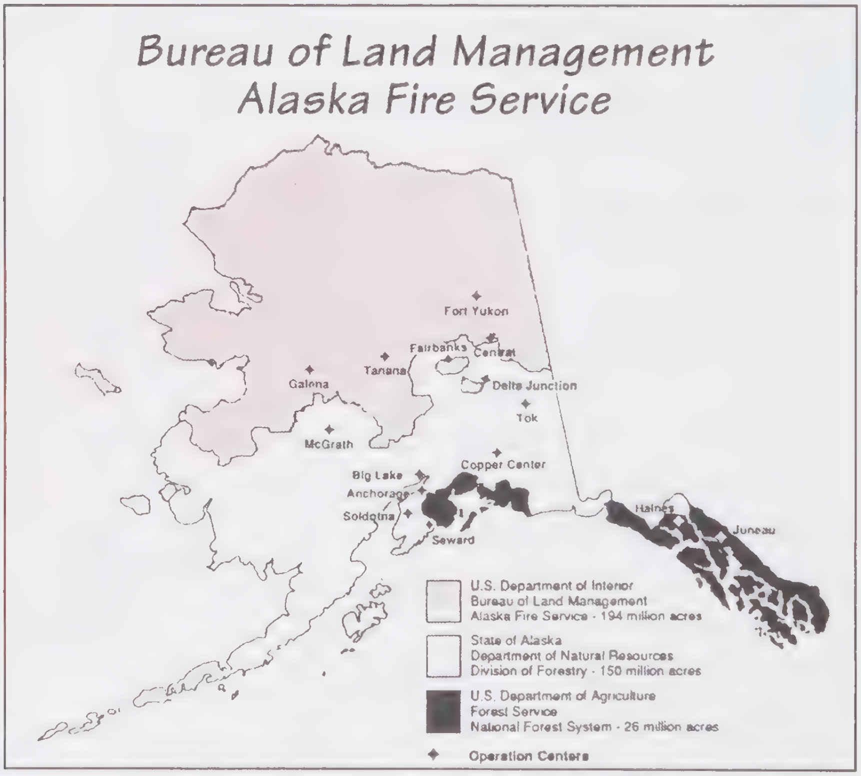
Figure 8.2 The Bureau of Land Management protects over 270 million acres in the 12 western states.

The bureau is responsible for the management and protection of these lands following the guidelines established in the Federal Land Policy and Management Act of 1976. These guidelines require the agency to manage in a manner that accommodates many uses of the land—such as fishing, camping, hiking, boating, grazing, timber harvesting, and mining. The bureau is also responsible for the wildland fire protection on their designated land.

BLM protects the land no one wanted.

Each of the 12 western states has an office that manages the bureau's business in that state. Within the 12 states, there are 59 district offices. In Alaska, the bureau manages the Alaska Fire Service (AFS). AFS is responsible for the protection of over 194 million acres of land owned by agencies of the Department of Interior, and state responsibility lands within its protection area (Figure 8.3).

The Alaska Fire Service protects over 194 million acres.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Galena
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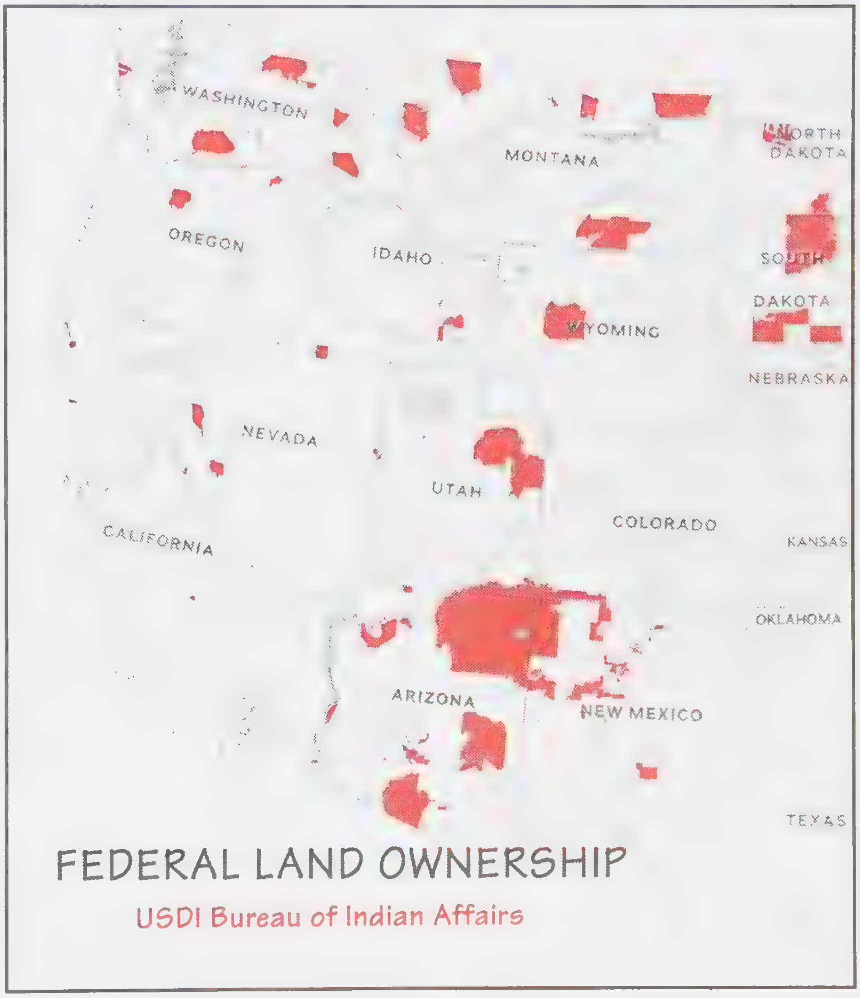
McGrath
Copper Center
Big Lake
Anchorage
Soldotna
Seward
Haines
Juneau
U.S. Department of Interior Bureau of Land Management Alaska Fire Service - 194 million acres
State of Alaska Department of Natural Resources Division of Forestry - 150 million acres
U.S. Department of Agriculture Forest Service National Forest System - 26 million acres
Operation Centers

Figure 8.3 The Bureau of Land Management manages the Alaska Fire Service. The AFS protects over 194 million acres of land owned by Department of the Interior agencies in Alaska. It also protects state responsibility lands within its protection area.

Bureau of Indian Affairs

The Bureau of Indian Affairs is an agency in the Department of the Interior. The bureau is responsible for the administration of federal programs for federally recognized Indian tribes, and for promoting Indian self-determination. It also has a "trust responsibility" emanating from treaties and other agreements with native groups.

In fulfilling its mission, the bureau provides federal services to about 1.2 million American Indians and Alaskan Natives who are members of more than 550 federally recognized tribes. It administers over 43 million acres of tribal-owned land, about 10 million acres of individually-owned land, and about 417,000 acres of federally-owned land which is held in trust status (Figure 8.4). The bureau operates 12 area offices and 83 agency offices. The role of the bureau has been changing; recently the tribes have been given much more control over their destiny.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FEDERAL LAND OWNERSHIP
USDI Bureau of Indian Affairs

Figure 8.4 The USDI Bureau of Indian Affairs administers over 43 million acres of tribal-owned land.

Fish and Wildlife Service

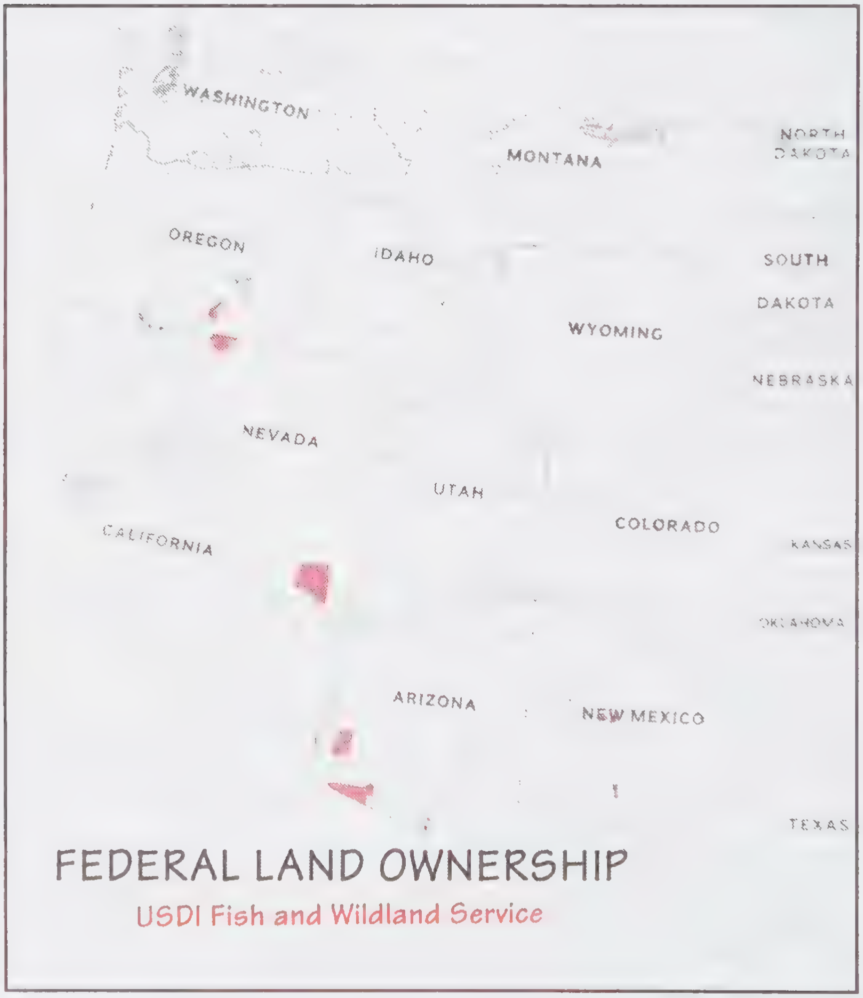
In 1871 the Congress established the US Fish Commission to study the decrease of the nation's food fisheries. The Fish and Wildlife Service had its beginnings in 1885 when Congress created an Office of Economic Ornithology to study migratory birds. In 1956 these two agencies merged. The new agency was named the Fish and Wildlife Service, and was placed into the

Department of the Interior. It manages 500 national wildlife refuges that range in size from a half-acre to thousands of square miles. In total, it protects 92 million acres of public land. The vast majority of this acreage is in Alaska (Figure 8.5)

The Fish and Wildlife Service has several roles, including protecting the nation's fisheries, managing the North American Waterfowl Management Plan, operating the hundreds of wildlife areas, and protecting endangered species. In fulfilling its role, the Fish and Wildlife Service has put increasing emphasis on two provisions of the Endangered Species Act—habitat conservation plans, and resolving conflicts between private development projects and the protection of an endangered species.

The majority of the 92 million acres managed by the Fish and Wildlife Service is in Alaska.

The Fish and Wildlife Service enforces the Endangered Species Act.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USDI Fish and Wildland Service

Figure 8.5 The vast majority of the lands controlled by the Fish and Wildlife Service are in Alaska.

As a fire officer, the area where you will most likely come into contact with the Fish and Wildlife Service is in its enforcement of the Endangered Species Act.

National Park Service

The National Park Service can trace its history back to the passage of the Yellowstone National Park Act of 1872 when, for the first time, public land was preserved for public enjoyment.

The Park Service itself was created when President Woodrow Wilson signed the National Park Service Organic Act on August 25, 1916, establishing it as an agency in the Department of Interior. Its mission is to "conserve the scenery and the natural and historic objects and the wildlife therein, and to provide for the enjoyment of the same in such manner and by such means as will leave them unimpaired for the enjoyment of future generations." The national park system covers 80.7 million acres of public land.

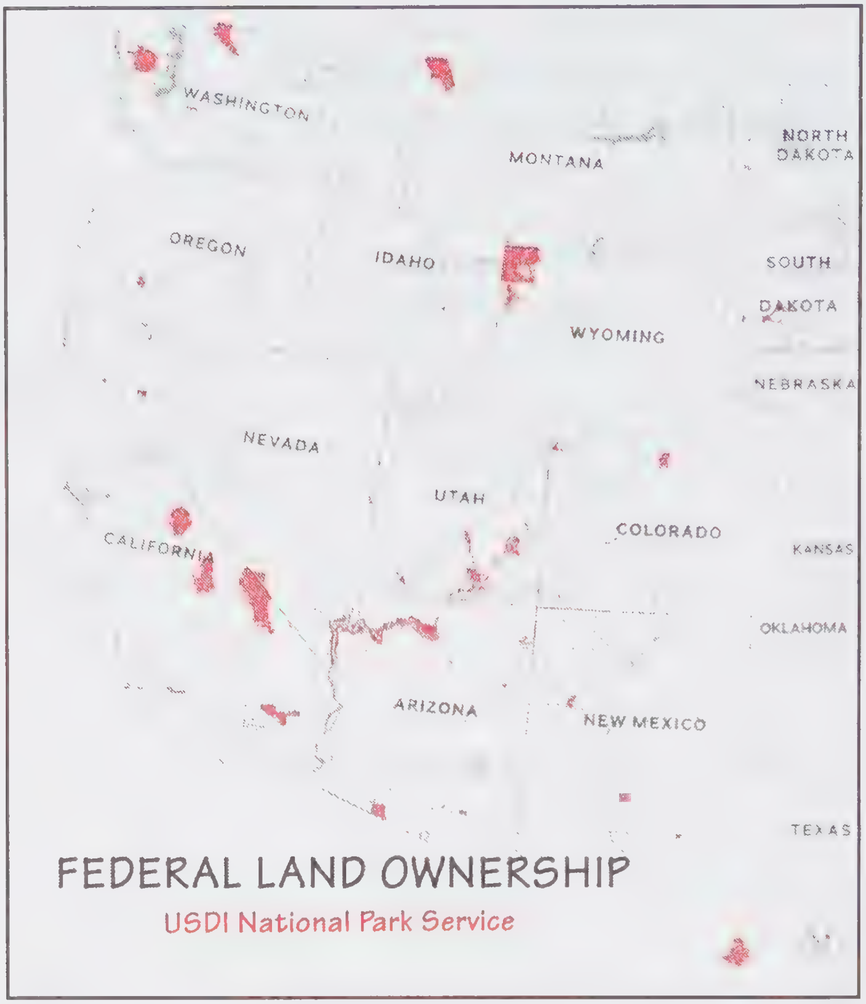
The National Park Service is responsible for conserving the natural and historic beauty of park lands.

As you can see, this is a totally different mission from the Bureau of Land Management and the Forest Service. That is why the National Park Service is very cautious in how it manages fire protection on the National Park lands. Until the early 70s, the National Park Service fought fire on its lands much like the other federal agencies. But, it eventually realized that the exclusion of fire was contrary to its basic mission of saving the land for future generations. If fire was excluded, the natural ecosystems would evolve differently, thus changing the future.

The National Park Service modified its fire policy in 1972 to allow fire to be a natural part of its management scheme.

The "let burn" policies came to a head in 1988, when Yellowstone National Park was ravaged by fire. It is not that the fire was all that bad, but the public didn't understand what was happening to the "jewel" of their park system. If the National Park Service did anything wrong, it was that it hadn't educated the public, the media, and the fire service on what it meant to "let burn." Since 1988, the federal agencies have streamlined their natural prescribed fire policy. ("Let burn" is no longer in their vocabulary.) They have also expended considerable effort educating the public about why fire is a necessary part of our natural world.

The term "let burn" is no longer "in." It is "prescribed natural fire" now.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FEDERAL LAND OWNERSHIP
USDI National Park Service

Figure 8.6 National Park Service has extensive holdings throughout the western states.

There are 369 national parks.

There are 369 national parks, seashores, battlefields, and other historic monuments managed by the National Park Service (Figure 8.6).

The Department of Defense provides protection to millions of acres of wildland area.

Department of Defense

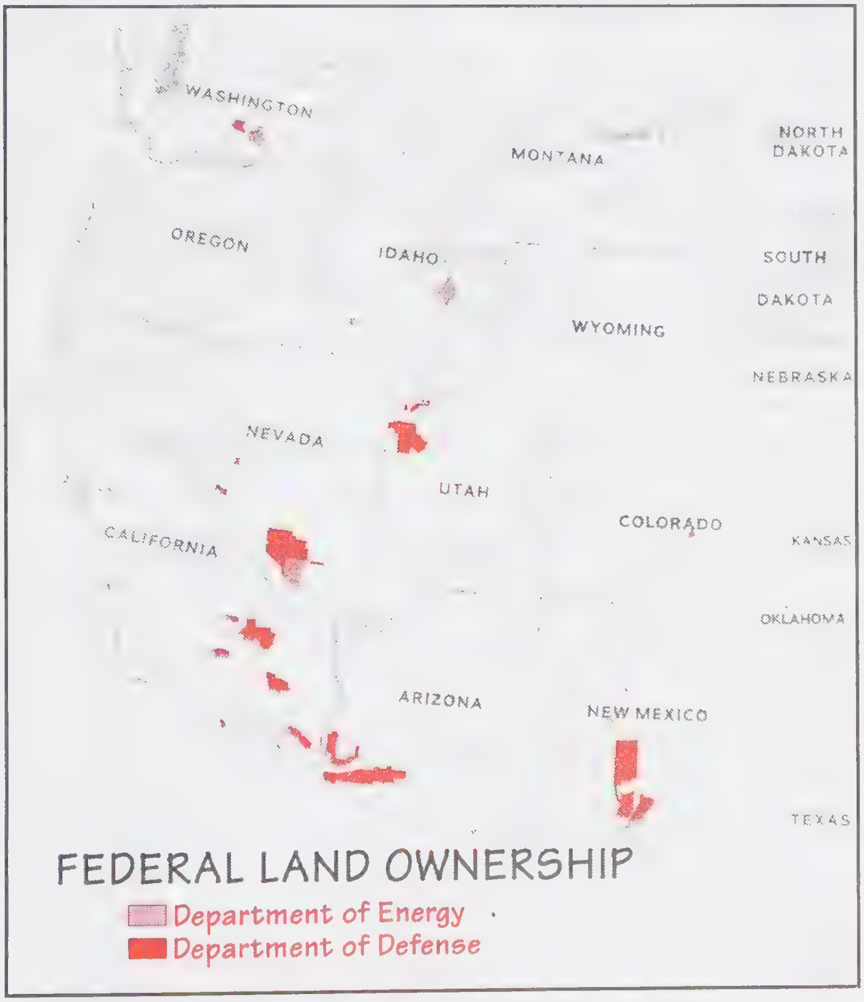
The various agencies within the Department of Defense (DOD) manage millions of acres of wildland (Figure 8.7). Usually nonmilitary firefighters only become involved with a fire on military lands when the fire threatens to escape outside the base. It is not a wise thing to venture onto military training areas without a very good idea what you are doing. Remember, the military has some very unique ways to start fires (e.g., bombs, rockets, flares, tracer bullets, etc.) (Figure 8.8).

The DOD is now a provider of aircraft and troops during periods of maximum drawdown of wildland firefighting forces. For years, the military, through various State National Guard units, has provided eight MAFFS airtankers. MAFFS stands for Modular Airborne Firefighting Systems. This 3,000 gallon system is installed in military Lockheed C-130 aircraft. The retardant is forced out of the aircraft through two large nozzles using air pressure. These units are to be activated only after the regular airtanker fleet is fully committed.

The MAFFS airtankers are operated by the military in support of federal and state wildland fire agencies.

As noted above, the military is now a frequent provider of firefighters when the regular forces are depleted. When the decision is made to activate the military, it takes about a week to train and deploy them. These forces are managed differently from

The military also provides troops for firefighting when regular forces are all committed.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FEDERAL LAND OWNERSHIP
Department of Energy
Department of Defense

Figure 8.7 The Department of Defense and the Department of Energy both protect millions of acres of wildland.

You definitely want to be careful (and informed) when fighting fire on a military base.

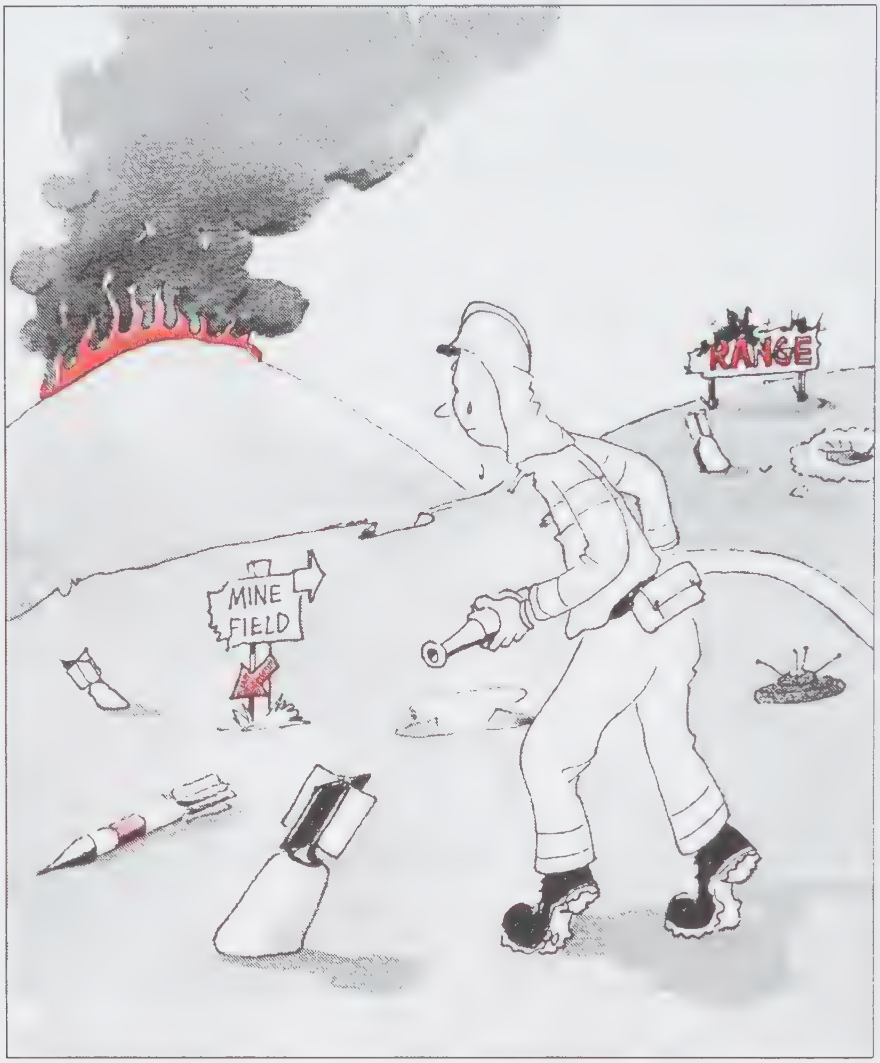


Figure 8.8 Are you sure that you want to fight fire on military land without a guide?

other firefighting forces in that command and control of the forces never leaves the control of the military. Skilled firefighting personnel are assigned to each squad to provide technical advice.

FEMA's role has changed dramatically over the last 25 years.

Federal Emergency Management Agency

The Federal Emergency Management Agency (FEMA) is an organization without a specific "jurisdiction." But it comes into play when an emergency situation develops into a disaster. FEMA's role has been evolving over the last 25 years. Then it became involved in nationally "declared" disasters. Its role then grew into funding the cost of state and local response to disasters—a kind of "welfare" payment system for state and local entities. It still funds some response costs, but it is becoming more focused on mitigation to reduce the damage from natural disasters.

The Director of FEMA is a Cabinet-level officer (at the same level as the Secretary of State, the Secretary of Defense, etc.) appointed by the President. The National Fire Administration and the National Fire Academy are part of FEMA.

FEMA's main contact with fire agencies is through the state level emergency services organizations. It has some direct contact with the 18 Urban Search and Rescue Teams. By federal policy, the USDA, Forest Service provides any necessary fire-related expertise to FEMA.

FEMA's main contact with local agencies is through the various state level emergency services departments.

National Fire Administration

The National Fire Administration manages the **National Fire Academy** located at Emmitsburg, Maryland. The National Fire Academy conducts specialized training courses and advanced management programs on issues with national impact. These courses and programs are offered in a concentrated, residential setting that is very conducive to intensive learning.

The National Fire Academy offers courses in executive development, management sciences, emergency medical services, incident management, planning and information management, hazardous materials, arson, fire prevention, public education, and training.

Occupational Safety and Health Administration

The Occupational Safety and Health Administration (OSHA) was established by the Occupational Safety and Health Act of 1970. It was "an act to ensure safe and healthful working conditions for working men and women; by authorizing enforcement of the standards developed under the act; by assisting and encouraging the states in their efforts to ensure safe and healthful working conditions; by providing for research, information, education, and training in the field of occupational safety and health; and for other purposes."

The National Fire Administration is part of FEMA.

As you can see from this preamble to the legislation establishing OSHA, it was given very broad authority. It has evolved into a very influential organization. One of the provisions of the law was the encouragement of the states to administer the program; many states have done so. In those states, the federal law is used to enact and enforce safety.

OSHA is responsible for ensuring a safe working environment.

Both State and Federal OSHA programs have the power to levy fines and bring criminal charges before the courts for violation of regulations. These actions can be taken against corporations, managers, and/or supervisory personnel.

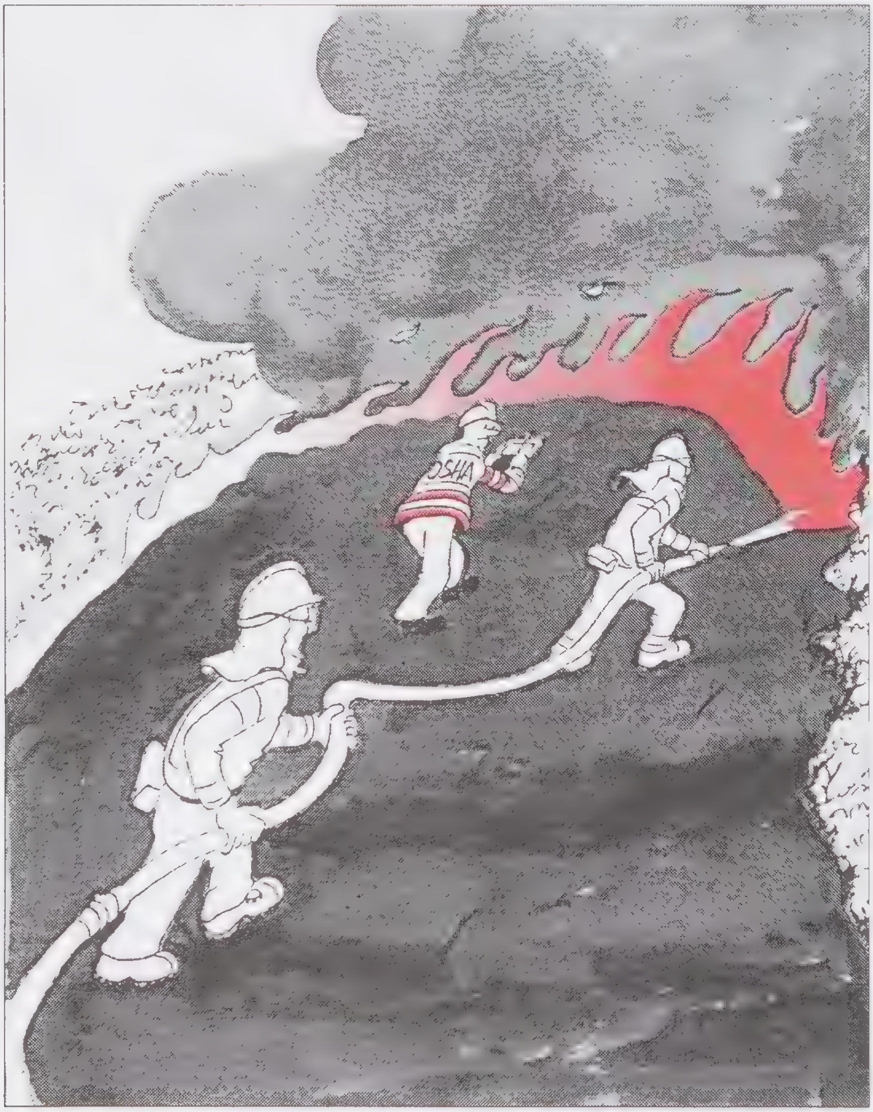


Figure 8.9 OSHA is looking over the shoulder of this fire officer. OSHA should not be of concern if you are following all of the operational procedures established by your agency. If you elect not to follow these procedures, and someone gets seriously injured, you may be headed for real trouble.

In a business like firefighting, an inherently dangerous business, OSHA is always looking over your shoulder (Figure 8.9). We saw that after the South Canyon Fire. OSHA conducted its own investigation, and took administrative action against Bureau of Land Management and Forest Service management personnel. OSHA did not take direct action against the supervisory personnel on the fire, because it felt the root cause of the accident was at a higher level in both agencies. But it could just as well have taken punitive action against people much farther down in those organizations.

When firefighters are seriously injuried or killed, you can expect, at a minimum, an inquiry by an OSHA inspector. It is best for management to be open, straightforward, and cooperative with OSHA. After the South Canyon Fire, the Bureau of Land Management and the Forest Service were diligent enough in conducting their own investigation of the fire that it placed them in a favorable light with OSHA.

OSHA has the power to cite and take civil and criminal action.

One important thing to remember is that OSHA generally uses established standards and procedures to help determine if an action was conducted using "best practices." It may use either standards established by the individual fire department or those that have been adopted by an organization like the National Fire Protection Association (NFPA). This means that even though your fire agency may not have adopted NFPA standards, your actions may be judged by these standards. It is good practice to review your standards and procedures against NFPA standards as part of a commitment to safety.

State Agencies

The woods are considered a work place, just like a factory or office building.

State Forestry Departments

Some of the states have established state forestry organizations to protect the forests or range lands in the state. Each state has given these organizations different responsibilities and authorities. Some of the differences are as follows:

> The **Alaska** Division of Forestry is responsible for the protection of about 150 million acres (104 million acres of state land, 44 million acres of federally owned land, and 2 million acres of private and borough-owned land) (Figure 8.3). Fire protection is funded by state general funds.
>
> **California** has the largest state forestry organization in the United States in terms of budget and personnel. The California Department of Forestry and Fire Protection (CDF) is responsible for the protection of all wildlands not under federal protection or within an incorporated city. CDF is responsible for the protection of about 35 million acres in the state. It also has the authority to provide cooperative fire protection services—over a third of the CDF firefighting personnel are paid for by local government, under agreements. CDF operates over 1,100 state or locally

All of the states operate their state forestry organizations differently.

funded fire engines. The protection of private wildlands is funded by the state's General Fund. Local government fire protection is paid for by the local jurisdictions.

Colorado Forest Service does not have a direct protection responsibility. State law gives the responsibility for the protection of private lands to the county sheriffs.

CDF is the largest of the state organizations.

Montana Department of Natural Resources and Conservation is responsible for the protection of 5 million acres of state- and privately-owned forest lands, including timberlands within cities. It also protects private lands, if funded by an assessment fee.

Nevada Division of Forestry has a mission similar to California's, but local fire authorities can assume the protection responsibilities if they want. Since property tax is used to fund the division's operation, they are required to provide year-round protection.

The county sheriffs in Colorado are responsible for the wildland fire protection on private lands.

Oregon Department of Forestry protects 16 million acres (855,000 acres of state land; 10.4 million acres of private forest land; and 4.8 million acres of BLM land in central Oregon). The department's fire protection services on private lands are funded by property tax assessments.

You should know and understand the responsibilities and authorities of the state forestry organization in your state.

State Emergency Services Departments

Every state has a department that coordinates its relationship with the Federal Emergency Management Agency and local government emergency services organizations. All have their roots in civil defense type activities.

These organizations usually come into play when an incident is declared a disaster. In those states where there is a statewide mutual aid system, the emergency services agencies usually coordinate the statewide movement of fire apparatus. In California, the Office of Emergency Services also has 105 engine companies (staffed by local government fire departments) that are available for dispatch to any disaster in the state. In 1988, ten of these engines fought fire in Yellowstone.

State Fire Marshals

Most states also have a state fire marshal. In general, the state fire marshals' organizations provide fire service training, and inspect multiple occupancy structures like nursing homes, jails, hospitals, etc. In some states the State Fire Marshal's Office coordinates the statewide mutual aid system.

All states have an OES department.

Local Government Agencies

Incorporated Cities

The basic form of government in this country is the incorporated city, town, or village. In most states, cities are formed to provide services to their residents; fire protection is one of these services. Usually the city fire department provides all of the fire protection needs within the city limits. In Montana, the protection of timbered lands remains with the state.

County or Borough Fire Agencies

Not all states have state fire marshals.

Counties, townships, or boroughs are the next layer of local government. They may provide some of the same services as cities, but fire protection is usually permissive, not required. This means this level of government can provide fire protection if the people vote for that service.

Since fire protection is usually permissive, if the state has assumed the responsibility for wildland fire protection, there can be an overlapping jurisdictional responsibility where structures are located in wildlands.

Cities are usually responsible for all fire protection needs within city limits.

Fire Authorities

The use of fire authorities to provide fire protection is a growing phenomena. A fire authority is an organizational structure authorized by a cooperative agreement *between two or more jurisdictions* to provide fire protection. The fire authority is managed by a board, usually made up of people from each of the jurisdictions.

Counties can provide fire protection.

Fire Protection Districts

The use of fire protection districts to provide fire protection is very common. Fire districts (and other forms of special or service districts) constitute a fourth level of government. In some states, fire districts provide all of the fire protection responsibilities within the boundaries of the district. In others, wildland fire protection may remain with the state, creating overlapping protection responsibilities.

A fire authority is a fire agency that is established by agreement between separate jurisdictions.

Service Areas

Service areas are formed to provide increased levels of public service. The services may be for street lighting, water and hydrant services, police services, or fire protection. A service area is an extension of an existing jurisdiction. This means a county or city may form a service area to provide a higher level of service than provided elsewhere in the jurisdiction.

Volunteer Fire Companies

A volunteer fire company is usually not a formal form of government, but an association of people who provide fire protection in their community. Volunteer fire companies may receive their funding from subscription or fund raising activities. This type of fire protection is usually found in rural areas.

Districts can provide fire protection and many other types of services.

Private Agencies

Timberland Owners

The timberland owners have been providing fire protection to their lands for years. In most areas, when governments started to provide wildland fire protection on private lands, fees were charged for the service. In some states, fees are still levied on private lands for this protection.

Most firefighters are volunteers.

Timber Protection Associations

In some areas, timberland owners form associations to provide wildland fire protection. The association levies fees on its members; this revenue is used to fund fire protection.

Fire Brigades

Some private companies use fire brigades to provide fire protection on their lands or at their facilities. These brigades are staffed by employees who become firefighters when the alarm is sounded.

Most of the timberlands in the United States are owned by private citizens.

Fire Protection Companies

When Ben Franklin formed the first fire organization in this country, it was funded by subscription or an insurance premium. Insurance companies were in the fire protection business long before governments assumed the responsibility. Fire protection companies provide fire protection services, under contract to governmental jurisdictions. The largest private fire protection company in this country is Rural/Metro Corporation, headquartered in Scottsdale, Arizona.

Brigades are usually tied to industry.

Associations, Fire Councils, and Groups

National Association of State Foresters

The National Association of State Foresters (NASF) is a national organization that represents the directors of the state forestry agencies from all 50 States, 5 of the US territories, and the District of Columbia. The state forestry organizations aid the owners of over 60 percent of the forests in the Nation. NASF is primarily a lobbying organization with its headquarters in Washington, DC.

Private corporations can provide competitive and professional fire protection.

National Wildfire Coordinating Group

The National Wildfire Coordinating Group (NWCG) is charged with the coordination of the wildland fire protection efforts for the various federal firefighting agencies. The voting members include representatives from the following:

- USDA Forest Service
- USDI Bureau of Land Management
- USDI National Park Service
- USDI Fish and Wildlife Service

- USDI Bureau of Indian Affairs
- State Forester from an eastern state
- State Forester from a western state

The associated, nonvoting members of NWCG include:

- US Department of Defense
- US Fire Administration
- National Fire Protection Association

NWCG is a very important MAC operation.

NWCG sponsors several "working groups" that provide staff direction for the parent group. These working groups cover such issues as national level training, the Incident Command System, prevention, and safety.

National Fire Protection Association

The National Fire Protection Association (NFPA) has been in existence for over 100 years. There are over 68,000 members from 70 countries. NFPA is predominantly involved with all aspects of structural fire protection, but in the last 10 years or so, has become more involved with wildland fire protection. Its main focus is on the development of fire protection related standards. There are more than 300 NFPA standards, that cover a full range of topics, including fire engine design and complement, interior sprinkler systems, high rise alarm systems, protective safety gear, and airplane hangers.

The standards that relate to safety issues can and will be used by OSHA as "industry standards" and can be applied to your operation whether or not your agency has adopted them.

NFPA develops standards that have tremendous impact on how we do our business.

There are several standards relating to wildland fire protection. Specifically they are:

- **NFPA 295** - Wildfire Control - This standard presents fundamental information to fire departments on the control of wildfire burning in natural and other vegetative fuels. The standard recognizes that protection of structures in wildland areas may require modification of strategy and tactics to allow for protection of those structures. It includes important information on safety procedures and practices, as well as other topics that are essential for the safe and successful control of wildfires.

- **NFPA 297** - Telecommunications for Rural Forestry - This standard focuses on four basic elements in the communications requirements of fire protection agencies. Included are communications between the public and the fire agency, communications within the fire agency under emergency and non-emergency conditions, communication among fire agencies, and communications between the fire agency and other agencies.
- **NFPA 298** - Foam Chemicals for Wildland Fire Control - This standard specifies requirements and test procedures for foam chemicals used on Class A fuels.
- **NFPA 299** - Protection of Life and Property from Wildfire - This standard presents minimum planning criteria for the protection of life and property from wildfire. It includes information and safe procedures and practices at the wildland/urban interface and intermix. The purpose of this standard is to provide criteria for fire agencies, land use planners, architects, developers, and local government for firesafe development in areas that may be threatened by a wildland fire.
- **NFPA 1051** - Wildland Firefighter Professional Qualifications - This standard documents the minimum skill and qualifications required to be a professional wildland firefighter.
- **NFPA 1141** - Planned Building Groups - The purpose of this standard is to consolidate into one document the necessary requirements for the prevention or minimization of loss of lives and property that may result from fire in buildings that are a part of planned building groups. Planned building groups are multiple structures constructed on a parcel of land that is under ownership, control, or development by one individual, corporation, partnership, or firm (excluding farms, manufactured home parks, and communities and recreational campgrounds).
- **NFPA 1231** - Water Supplies for Suburban and Rural Firefighting - This standard identifies minimum requirements for water supplies for firefighting purposes in rural and suburban areas in which adequate and reliable water supply systems for firefighting purposes do not exist.
- **NFPA 1561** - Fire Department Incident Command - This standard outlines an organizational structure that can be used by fire departments to manage emergency operations.
- **NFPA 1600** - Recommended Practice for Disaster Management - This standard documents the minimum requirements on preparedness for, response to, and recovery from disasters resulting from natural, human, or technological events.

OSHA can use NFPA standards to establish an "industry standard." Even if you haven't adopted them, they may apply.

NFPA 299 is a standard that deals with the wildland/urban issue.

NFPA 1051 establishes minimum qualifications for wildland firefighters.

- **NFPA 1906** - Wildland Fire Apparatus - This standard documents the minimum requirements for design and performance of a wildland fire apparatus.
- **NFPA 1977** - Wildland Firefighting Protective Clothing and Equipment - This standard documents the minimum requirements for protective clothing and equipment that provide hand, foot, torso, limb, and head protection for wildland firefighters.

NFPA 1977 establishes standards for wildland firefighting protective clothing.

These standards are developed by various technical committees. Each committee has members that are interested in the particular subject area or standard. One third of the committee membership can be from fire department management, one third from labor organizations, and one third from industry. Development of a standard takes years.

Coordination Centers and Groups

There are several coordinating centers or groups that you should be familiar with.

National Interagency Coordination Center

The National Interagency Coordination Center (NICC) is located in Boise, Idaho. This is where the federal wildland fire agencies coordinate the movement of firefighting resources between the various federal, regional, and zone dispatch centers and the Canadian Interagency Forest Fire Center (CIFFC).

NICC is staffed by representatives from the Forest Service, Bureau of Land Management, Fish and Wildlife Service, National Park Service, and a person who represents the state foresters. The federal representatives have the authority to set priorities and move resources accordingly.

Each morning during the fire season, NICC prepares a summary of national fire activity from the previous day and a report on any major fires. This report is available on the various federal e-mail systems and through the internet.

NICC is in Boise, Idaho.

Interstate Compacts

Several regions in the nation have found it necessary to form interstate compacts or agreements. The first of these was formed in the Northeast following the devastating fires in the late 1940s. The northeastern states have a compact that they use to move firefighting resources. There is a compact between the western states that was first used in 1977. There is another between the lake states and in the south. Since the Civil War, all interstate compacts require congressional approval.

Geographic Boards

Geographic Boards are coordination committees between federal and state agencies in various areas. They are normally referred to as Coordinating Groups. There is a Coordinating Group for each of the Forest Service regions. During periods of major fire activities, these groups convene and function as a Multi-Agency Coordination committee.

Coordinating Groups meet several times a year to manage the National Management Team (Type 1) makeup, set the priorities for national level training, and coordinate interagency activities. The agency representatives are usually the chief fire managers for the respective agencies.

State Fire Mutual Aid Coordination

Not all states have master fire mutual aid agreements. Where they exist, they allow for the movement of local government firefighting resources between fire departments. If a statewide agreement doesn't exist, each fire department has to have an individual agreement with other departments they will be assisting.

California has one of the most comprehensive state fire mutual aid agreements. This system operates under the authority established in the 1950s. It allows each and every governmental entity to assist any other entity. Assistance is coordinated at the statewide level by the Governor's Office of Emergency Services. Local and regional coordination is provided by fire chiefs selected by their peers. The system is capable of mobilizing over a thousand engine companies in a very short period of time.

In the state of Washington, the state's Emergency Management Division, in conjunction with a "Fire Defense Board" made

The daily national fire activity report provides timely information on major fires.

Ever since the Civil War, Congress must approve all agreements between the states.

Geographic boards are the regional MAC organizations. They will become more influential as time goes by.

Mutual aid systems will become more important as budget reductions impact base line budgets.

up of city and district fire chiefs, manages the statewide fire mutual aid system. In Oregon, the coordination of the mutual aid system is provided by the Office of the State Fire Marshal. Montana's system is organized in the same way as California's, but the Montana Department of Natural Resources and Conservation coordinates the movement of resources on a statewide basis.

9

Role of the Fire Officer

Command Presence and Versatility - It is critical that the fire officer be a calming presence and be prepared to fill just about any role at the scene of an emergency. It is imperative that the fire officer remain calm, cool, logical, competent, and in charge. This will only be possible if the fire officer is trained, experienced and confident in his/her ability. Remember the saying, "Be like a duck. Above the surface…look composed and unruffled. Below the surface…paddle like hell."

The fire officer is the most versatile position in the fire service. The fire officer can be a battalion chief, can be in charge of an engine company, or can be a training or fire prevention officer. On the fire ground the fire officer can be an Incident Commander, Division/Group Supervisor, Strike Team Leader, or a communications specialist. A fire officer can fill just about any function in the fire service.

For all intents and purposes, this whole book is about the role of the fire officer, whether it be understanding the impact of terrain, weather, and fuels, or being a good leader.

This chapter will not discuss how to fight fire, how to lead a group, or how to conduct a class. The focus here is on the specific responsibilities of the fire officer. However, we will begin by briefly reviewing some of the general leadership qualities and responsibilities previously discussed in this book.

Good fire officers are:

- Honest.
- Forward-looking.
- Inspirational.
- Competent.
- Good listeners.
- Fair and consistent.

In this chapter, you'll

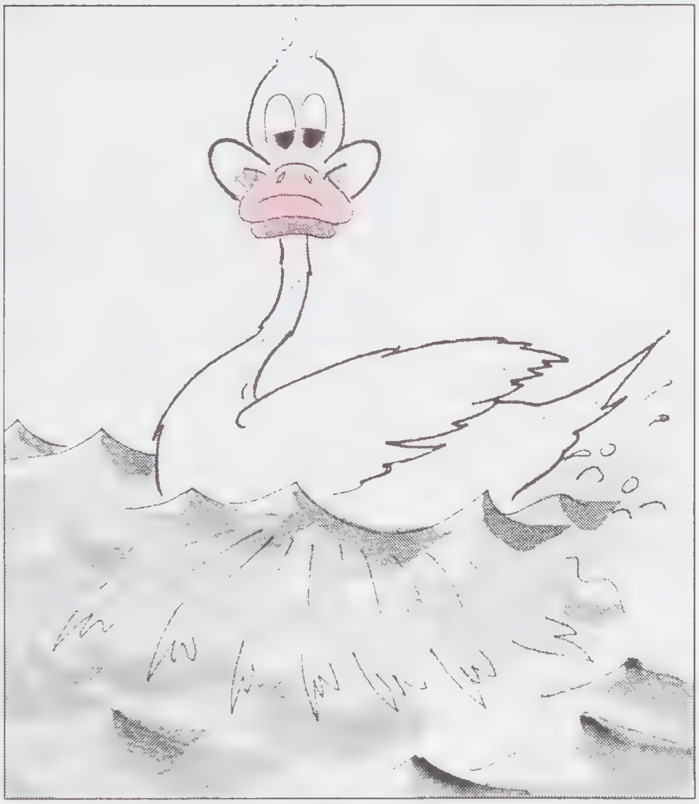
- *Learn that the primary role of a fire officer is that of a safety and training officer.*
- *Learn the responsibilities of a Company Officer.*
- *Learn the responsibilities of a Strike Team Leader.*
- *Learn the responsibilities of a Division/Group Supervisor.*
- *Learn the responsibilities of an Initial Attack Incident Commander.*
- *Learn what you should do to be ready for a fireline assignment.*

Good fire officers know how to:

- Motivate people.
- Delegate authority.
- Discipline appropriately.
- Conduct successful meetings.
- Think strategically.
- Maintain high morale.
- Manage conflict (or agreement).
- Give (and take) constructive criticism.

First and foremost, **the good fire officer has a passion for safety and commitment to training.**

Two of the primary responsibilities of the fire officer are to act as a safety officer, and to provide or arrange for comprehensive training.



This duck is calm above the waterline, but paddling like "hell" below the water. This is how a fire officer should act.

The primary role of a fire officer is to be the safety officer for his or her crew.

Acting as a Safety Officer

As a fire officer, you are the first level safety officer in the fire service (Figure 9.1). Your primary function is to take direct action to ensure that the firefighters perform their duties in a safe and effective manner. Specifically, the fire officer should be observant for, and take action to reduce or eliminate, work errors, unsafe acts, or other conditions that may cause injury or death.

Some specific responsibilities of the Safety Officer are to:

- Set a personal example of safe behavior, and to enforce safe practices and procedures.
- Provide training in an effort to develop and improve the skills of the firefighters.
- Ensure the proper use of personal safety equipment and firefighting equipment.
- Continually observe the performance of all personnel assigned, and immediately call attention to and correct work errors of any type.
- Inspect personnel and equipment each morning or at the beginning of each shift.

- Report to a supervisor any problems which need action by a higher authority.

Following are some general safety considerations that you should keep in mind:

Figure 9.1 The fire officer is the first level and most important safety officer in the fire service.

- Fatigue is one of the most overlooked causes of unsafe acts. When firefighters become tired, they begin to forget or choose to ignore some of the things they've been taught. Good physical conditioning is important, and appropriate nutrition and rest periods need to be provided to minimize fatigue.
- Firefighters will normally take more risks than management would like. This may be tied to the fact that firefighters take risks because they don't want to fail. Encourage your personnel to take pride in safe attitudes and practices.
- When structures are not threatened, firefighters can pick where they will fight the fire. When structures are involved, the fire determines how and where the fire will be fought. This is a significant safety concern. Be sure your personnel are well trained in structure protection. Also, foster in them the conviction that no house or property is important enough to take unnecessary risks for.

Fatigue can lead to unsafe acts!

Encourage your personnel to take pride in safe attitudes and practices.

When structures are involved, the fire determines how and where the fire will be fought.

Providing Training

There has been a great deal of discussion lately about the need to have a "passion for safety." It is felt by some that this doesn't go far enough. For instance, it is felt that fire agencies need a "passion for training." A "passion for safety" is ultimately an individual attitude, whereas a "passion for training" should be the commitment of the agency and its leaders. It is the responsibility of the fire officer to encourage this "passion for safety" and to personally develop a "passion for training."

There are many kinds of training. Examples are reading handbooks, attending formal training classes, or participating in live fire drills. Each has its place and all are necessary. But the training that will have the most impact is the manipulative skill drill and other such company-level training. It is at this level where firefighters hone their skills and, through repetition, move some skills to the subconscious. Remember the discussion about how firefighting was like driving a car? It is through repetition that you learn to step on the brake without consciously thinking about it. The subconscious senses a need to slow and responds appropriately. Training to the point where some knowledge and skills become automatic increases the likelihood that a firefighter will continue to react appropriately even under severe stress and danger.

You must train your subconscious to react.

Some of the specific forms of training are technical training, manipulative drills, realistic simulation training, company level drills, multi-company drills, and live fire training.

Technical Training - As noted above, a firefighter can secure technical knowledge through reading training material, watching video tapes, or by attending training sessions. You should make every effort to have training materials available for your firefighters. You should also ensure that you keep up to date on the latest information available. You wouldn't go to a doctor who didn't keep his skills current. Why should a community have firefighters who aren't current? Gaining technical training is not doing, it is just the gaining of knowledge. Since firefighting is a combination of knowing what to do and then actually doing it, your training can't stop at reading this handbook, watching a video, or attending a class. You have to get out there and tie that knot, throw that ladder, take the weather, lay that line, cut that undercut line, or be a Strike Team Leader.

Firefighters have a right to adequate and appropriate training.

Drilling helps makes perfect and permanent.

Manipulative Drills - During manipulative drills, you take what you've learned from technical training and begin to refine the skills through frequent repetitive drills. When you do this type of training, you "activate" the subconscious part of your brain. This is the part of the brain that controls many of your reactions when you are in flight or don't have the ability to consciously think through an event.

Realistic Simulation Training - Simulation training is a substitute for experience. There are not enough large fires to provide an opportunity for all firefighters to get first hand experience. Of course you aren't going to get the smoke, heat, and bugs of fighting a real fire, but some of the simulation training that has been developed can really make you sweat.

Conduct realistic simulation to "gain experience."

You should attempt to develop realistic training for you, your peers, and your firefighters. Conducting realistic simulation training is usually beyond the efforts of one person. Work with your associates inside and outside your agency to develop a program. It will take some money to develop an effective simulation. However, if your agency truly does have a "passion for training," then a persuasive presentation of your proposed program should be successful in obtaining funding.

Start with the training of your company officers. There are fewer of them than firefighters, and they are your eyes and ears and the organizers of all of your firefighting efforts. They will then be better qualified to act as mentors and pass this training on to the firefighters.

Firefighting is not an individual event. It is a team event, so you should train as a team.

Company Level Drills - Company level drills are important, because this is where individual firefighters come together and begin working as a team. They bring their individual strengths and weaknesses together and take on tasks that are beyond the capability of one person. The firefighters and their fire officer start developing the skills they will need to function safely, effectively, and efficiently.

Multi-Company Drills - Multi-company drills are the logical next step in a plan to have highly skilled and effective firefighters. You should routinely be involved in drills with people you will have to work with in real emergency situations. If you will be working with people from other agencies on your emergencies, then you should train with them.

"Train as you fight; fight as you train."

Remember the saying, "train as you fight; fight as you train." Make the drills different, challenging, and as realistic as you can. Attempt to train in the woods, pulling line, backing down driveways, or surveying an area, looking for water or usable safety zones.

If you don't already conduct regular multi-company drills, start developing plans to do so. Ask your peers to help develop them. Make them fun, interesting, and exciting. Don't make them so complicated that you start looking for excuses not to have them.

Live fire training is most useful, but difficult to develop.

Live Fire Training - Live fire training can be one of the best educational tools you have. But it is also one of the most dangerous. During a training exercise, you don't normally have the same level of danger that is associated with a real emergency. In this situation, be exceptionally alert and cautious.

A live fire drill can involve something as simple as extinguishing a pan of fuel with a fire extinguisher, or as complex as an incident which involves many fire companies for an extended period. A live fire drill is very difficult to set up and conduct. First you have to find a landowner who will allow you to burn. Then you have to identify people who are motivated enough to help develop, plan, organize, and supervise a meaningful and realistic drill. Finally, you have to have a chief who will allow you to participate.

If you aren't in a position to develop your own live fire drill, try to get an invitation to one in your area, or start talking with your peers about jointly developing one. Start small; begin with a few departments and see where it leads you. Learn from others. Find out how they do it and copy it.

Make it a habit to analyze all of your operations.

Two practices which enhance knowledge, effectiveness, and safety are post-fire analysis and pre-fire planning.

Pos-Fire Analysis - All too often, a post-fire analysis, or critique, is considered a witch hunt looking for someone to blame for something that went wrong. This is usually the position taken by those who are not very sure of themselves. You should make it a habit to sit down with the crew after *every* response and discuss what went right, what went wrong, and what you will do next time in an effort to do better. **There is no better way to learn than learning from one's errors.** (An error is when you do something that isn't right; a mistake is where you make the same error twice.) This doesn't mean that you have to hang out all of your dirty laundry after each alarm. It means that if you did something wrong, you realize it, try to understand what made it happen, and attempt to correct it (Figure 9.2).

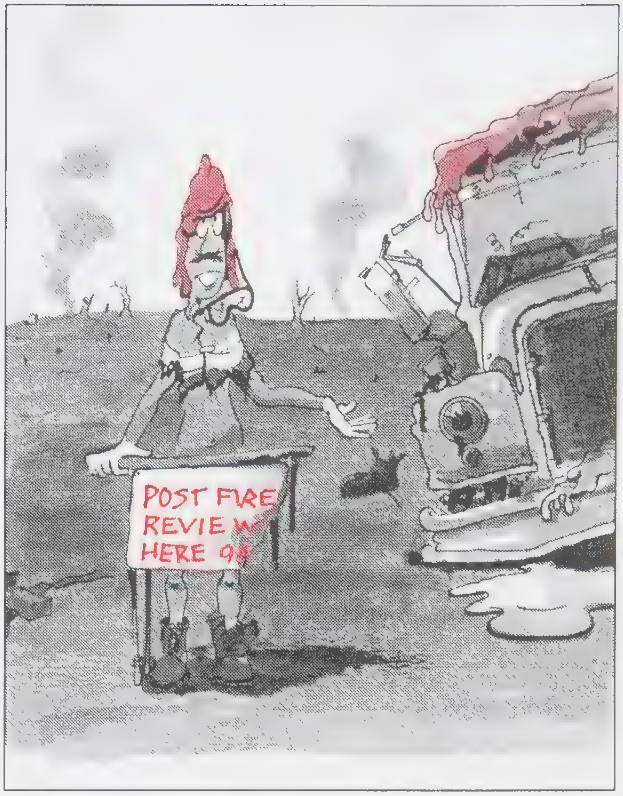


Figure 9.2 This fire officer is conducting a post-fire analysis with his crew. It is obvious they have something to discuss.

Some of the topics to be included in your group level post-fire review are:

- The fire behavior and weather.
- The strategy and tactics that were used.
- The use of firefighting resources.
- The level of cooperative agency involvement.
- The hazards encountered.
- Any injuries or accidents that occurred.
- The values at risk and whether they were dealt with properly?
- How the organization dealt with sensitive environmental or political issues.
- How you would correct any problems that were encountered.

Agency management has to take the lead in the critique of major alarms or events. They have to allow their organizations and themselves to be asked hard questions. They have to insist that every major event is critiqued and a report of key findings be distributed so all those interested can learn from it.

As a supervisor you should also discuss with your subordinates their actions on the fire. Some of the points you should cover are:

- Their level of performance, production, or output.
- The firefighting techniques they used.
- Their level of team involvement.
- Any safety issues.
- Overall general conduct.
- What training is needed to improve their level of performance.

Learn from what you did right and what you did wrong.

Pre-Fire Planning

Fire departments have been pre-planning large buildings for years. This activity not only provides an opportunity for fire companies to become familiar with the building, it also allows them the opportunity to "map" the building and to locate the access, firewalls, sprinkler hookups, etc. In wildland fire pre-planning, you'd be looking for such things as the best route in (access), any natural barriers, and water sources such as ponds, pools, or hydrants. There are many wildland areas or urban/wildland areas that can be realistically pre-fire planned.

You should analyze those locations, communities, tracts, or ranch buildings that may be threatened by a wildland fire. Be realistic in your plan. List the information that will be a real help to the user. Don't try to anticipate the disaster itself, because every disaster will be different. Concentrate instead on cataloguing helpful information.

Pre-fire plan your area.

Some feel that most disaster planning is an illusion. They feel that most plans are based on invalid assumptions, usually with unrealistic schedules and with no interorganizational coordination or involvement. Make sure that if you do take the time to develop pre-plans, they are not paper plans, but ones that will truly be helpful when a disaster strikes.

For your plan to be useful, there are several issues to be considered:

- Base your plan on what people are likely to do, rather than what they should be doing. The plan has to be helpful rather than instructional. It is too late to be doing training when the disaster strikes.
- For your plan to be effective, it must be interorganizational. This means that the plan has to be developed with the involvement of other organizations.
- The people expected to use the plans should be familiar with them. These people must also accept the plans as worthwhile and useful.
- Realize that the process of developing the plan is, in reality, more important than the written document.

In addition to safety officer and training officer, there are other roles the fire officer may be called upon to fill. Some of these are Company Officer, Strike Team/Task Force Leader, Division/Group Supervisor, and Initial Attack Incident Commander.

As a Company Officer

As a Company Officer, you will be responsible for the supervision of the people who actually fight fire. Even though company officers are usually considered "rank and file employees," they are first-level supervisors and must understand their responsibilities.

Company officers generally set the image for the company and as such should be:

- Self-confident and role models.
- Physically fit and ready to take on strenuous activities.
- Well-trained and have demonstrated their skills.
- Deeply involved in the training of the company.
- Able to develop rapport with their crews.

Strike Team Leaders are more than "baby sitters" for a group of engines or crews.

As a Strike Team/Task Force Leader

The Strike Team/Task Force Leader (STL) is one of the most misunderstood positions in the Incident Command System. Strike Team Leaders are more than record keepers and baby sitters. They have a real and very important role in the fire fight. How does the strike team fit into the overall plan?

Moving a strike team - When you will be traveling some distance it is important to keep the strike team together. The Strike Team Leader should be in a separate vehicle and take the lead. The slowest engine should be just behind the Strike Team Leader. If you have any units that are having communications problems, place them in the middle of the strike team. The units in the strike team should keep a good interval between them—not so much that they may miss a turn, but enough to allow cars to safely pass. If it is policy to place strike team identification in the window of the units, make sure that they are in place and easily seen.

You may have to form the strike team after they arrive at the fire.

If the response is "immediate need" and the strike team will not be forming up before traveling, be sure that all of the units are very clear as to whom they are to report and how to get there. Strike Team Leaders should have detailed information about the units they will be responsible for. When an "immediate need" dispatch is made, it means as quick as your wheels will get you there.

First impressions are lasting. Be prepared to fight fire.

Knowing where, when, and how to report to an incident - Most of the time, a strike team will be told to report to a staging area or incident command post. Once you arrive at the fire, your first responsibility is to inform the appropriate authority that you are there. You may be checking in with a Check-In Recorder at a staging area or the incident command post. You may be checking in with a Division/Group Supervisor. Regardless of who you check-in with, make sure that they have all of the required information. You should not be wandering around an incident without the leadership knowing you are there. If you were dispatched, it means you are needed for assignment. And you may not get paid or fed if nobody knows you are there.

First impressions are always lasting. If you want a good assignment, one where you might see some action, show up looking like you're ready for action. Be dressed properly, and ready to start to fight fire; have your engines ready. If you show up in T-shirts and baseball caps, with lawn chairs in the hose bed, you will be parked next to a house a long way from the fire, or worse yet, you might be placed in "reserve" in staging. You have been sent to the fire to fight fire, so be in the proper safety clothing and act like a professional. It is so simple to make a lasting impression. Make an effort to make it a good one.

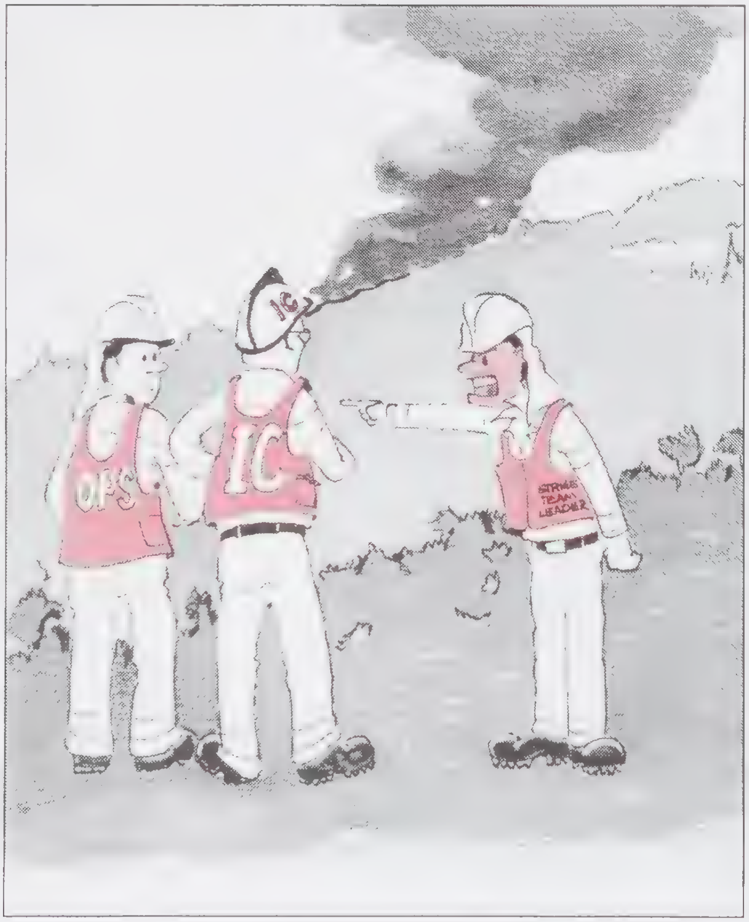


Figure 9.3 This Strike Team Leader is really upset that the IC wants to break up his strike team.

Breaking up a strike team - There are Strike Team Leaders who would inflict great bodily harm on anyone who suggested that their strike team was to be broken up (Figure 9.3). The first thing to remember is that there is no rule that says you can't break up a strike team. There is a general rule that says that if a unit is part of a strike team when it gets to the fire, it probably should return home with the strike team.

There are times that it is necessary for an Incident Commander to break up a strike team. If you have a need for one engine, why send five?

Rainbow strike teams - There may be times when the units assigned to a strike team may be from different departments or agencies (Figure 9.4). When units of "different colors" are formed into a strike team, they are called a "rainbow strike team" - a team of different colored engines. If you have to be involved with a rainbow strike team, it is best if the people involved have worked together before. It is tough if all the players are strangers.

When you mix units on a strike team, it may bring together people who work different hours, different duty shifts, and for different levels of compensation. Some people may be volunteers, some may be on overtime, and others will be lucky if they get compensating time off. There may also be very different policies and procedures. Some may be free to leave base camp during off duty hours; others may be restricted to camp. The Strike Team Leader is going to have to be familiar with any differences and take them into account to make the strike team function effectively.

You may have to supervise people that are paid a different wage and are on different duty shifts.

Captain vs. Battalion Chief - There is a constant debate regarding whether the Strike Team Leader can be a senior captain

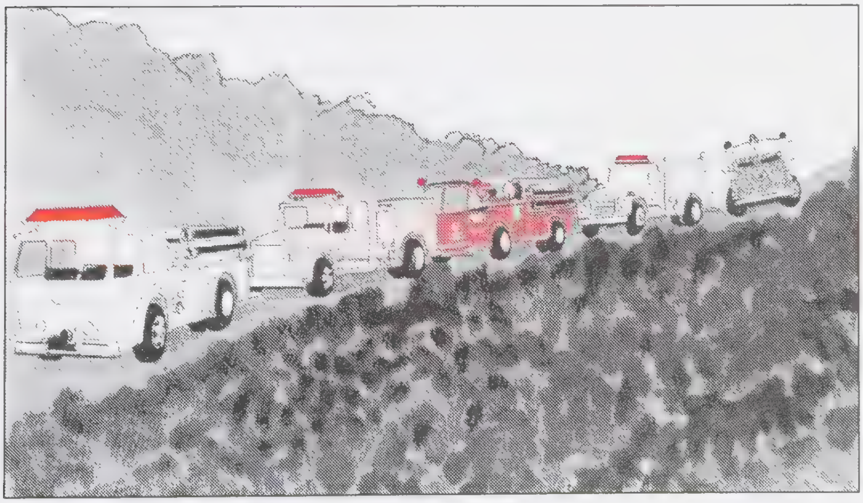


Figure 9.4 This "rainbow" strike team is about to go into action!

or whether the position always has to be filled by a higher ranking officer. Engine captains will say that they can fill this responsibility just fine. Battalion chiefs, or fire management officers, will tell you that it needs a higher ranking officer. In all cases, it needs someone who can lead, and rank doesn't really have anything to do with it.

In a department where rank is significant, an officer above the engine company officer is probably important. In a department where there are clearly very experienced company level fire officers who do a fine job as Strike Team Leaders, then they can fill the role. The key is the relationship between the engine company officers and the Strike Team Leader. The receiving agency needs to be assured that the Strike Team Leader has a functioning strike team, one where the various supervisors all get along.

The Strike Team Leader has fireline responsibilities.

Fireline assignments - There have been cases where units of a strike team have been assigned to a line assignment and the Strike Team Leader remained in base camp. This is not the role of the Strike Team Leader. Strike Team Leaders should be with the units on the line. They should receive assignments from the Division/Group Supervisor and ensure that the various units in the strike team carry out the orders. A Division/Group Supervisor should not be talking with individual units in a strike team. In a fireline assignment, the Strike Team Leader fills the role of a supervisor, and usually has a specific mission to carry out or a geographic area to protect. When the strike team is off the line, the role of the Strike Team Leader is totally different. In this role, Strike Team Leaders are responsible for the well-being of the various units. They are to ensure that people are fed and adequately cared for. They are responsible for ensuring that the units are maintained and repaired if necessary. The role of a Strike Team Leader is a tough one if it is done properly.

As a Division/Group Supervisor

The Division/Group Supervisor is one of the most important functions on the fireground. This is the level at which the suppression plan is implemented. The Division/Group Supervisor level is also where the plan, strategy, and tactics are set for the next planning period.

The specific responsibilities of a Division/Group Supervisor on the fireground are to:

- Ensure the safety of assigned personnel.
- Implement the assigned portion of the Incident Action Plan.
- Deploy the resources assigned to the division or group.
- Report on the progress of control operations.
- Maintain and report the status of assigned resources.

The Division/Group Supervisor is the first level of incident management.

Safety is, without question, the first consideration in setting the specific strategy and tactics that will be used by a division or group. As a Division/Group Supervisor, the fire officer is first and foremost a safety officer.

The Division/Group Supervisor is responsible for tactical deployment of the assigned firefighting resources for a specific area/role. The Division/Group Supervisor should fully brief all of the personnel assigned to the division/group on the status of the incident, the general strategies to be employed, and the specific tactics that will be used.

In order for Division/Group Supervisors to fulfill their roles, they must be fully familiar with the division's or group's function and area of responsibility. This may mean getting out of the vehicle and walking around. The size of the division should not be so large that the Division/Group Supervisor can't walk it or drive it at least twice during a shift. The division boundaries should be easily found. Use road intersections, ridge lines, or creeks as division boundaries when possible.

Do not make your divisions too large.

Some of the more specific responsibilities of a Division/Group Supervisor on the fireline are as follows:

Get the assignment - After reviewing the specific assignment with the supervisor (Incident Commander, Operations Section Chief, or Branch Director), develop the tactics that will be used. The Division/Group Supervisor then meets with the various crew leaders assigned to the division. If there is a formal Incident Action Plan, copies should be secured for each of the Strike Team Leaders assigned to the division.

Review safety issues - The Division/Group Supervisor should discuss the various safety considerations (e.g., aircraft and bulldozer safety, hazards associated with the terrain, powerlines, and other special hazards). There should also be a discussion on how to get medical help if it is needed.

Review LACES with all of your forces.

The weather and associated fire behavior should be separate safety topic. The forecast and the potential for changing conditions should be discussed. Review LACES and the conditions under which personnel and equipment are to be moved out of harm's way. Develop a prescription or parameters which tie actions to a change in relative humidity, wind speed and direction, time of day, or when the fire reaches a specific location. Establish clear-cut rules regarding when personnel should move off the line to safety.

Supervise the work in progress - The Division/Group Supervisor is responsible for monitoring the work in progress, coordinating activities with adjacent divisions or groups, making changes in the tactics when necessary, keeping supervisors informed of critical information or changes, and ensuring that the planning section is informed of any changes in status.

Provide simple concise instructions.

It is best if the Division/Group Supervisor actually observes the work in progress by walking, driving, or flying the division. But, if that isn't possible, he or she may have to rely on progress reports from the Strike Team Leaders and/or lookouts. Establish specific times for checking in and providing a short, concise report on conditions. Also, ensure that you are told of any delays in line construction, any unexpected occurrences, any accidents, or any logistical problems.

If an unexpected event does occur, be sure that the Operations Section Chief or Branch Director is informed.

Coordinate with adjacent supervisors - It is critical that you have contact with and coordinate your actions with adjacent divisions or groups. If this isn't done, there is a distinct possibility that the actions on one division will adversely impact the actions on another (Figure 9.5).

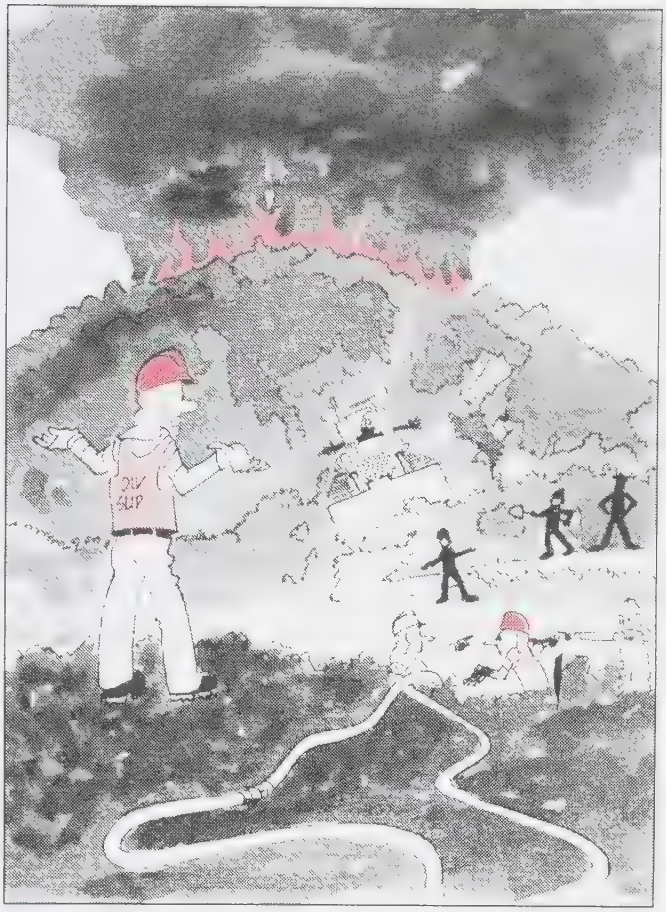


Figure 9.5 This Division/Group Supervisor did not coordinate with his neighbor and things are getting out of hand.

Review how the various divisions tie together and then establish a communications link with the other supervisors. Review your plans with them to see if there are any conflicts. If there are, the Operations Section Chief or Branch Director may have to intervene and resolve the conflict.

Maintain a Unit Log - You should keep notes of key events and actions. Maintain a unit log, so that you can refer to it later if need be.

Ensure the welfare of the troops - It is also the responsibility of the Division/Group Supervisor to look after the general welfare of the troops. Personnel must have adequate food, water, and rest breaks.

Planning for the next operational period - The Operations Section Chief and Division/Group Supervisor have a joint responsibility for ensuring that the proper resources are assigned to a division for the next operational period. Although most of the decisions regarding the assignment of resources will take place between the Operations Section Chief and the Planning Section Chief, these officers rely heavily on input from each Division/Group Supervisor.

As an Initial Attack Incident Commander

Every fire has an initial attack Incident Commander, and in most cases, it is a fire officer assigned to an engine company. It is estimated that 95% of all wildland fires are controlled during the initial attack phase of operations.

Your first responsibility as an IC is to develop a complete size up.

As the initial attack Incident Commander it is your responsibility to size up the situation, develop a plan of action, and deploy the firefighting resources of the first alarm. In most cases a fire in the initial attack phase of operations doesn't have a fully staffed command structure (Fire Information Officer, Safety Officer, etc.), with one exception. That is the development of a structure that has at least two divisions. This philosophy of assigning divisions early in an event has been mentioned before in this handbook. It is not mentioned to make a fire look bigger than it really is, but to make the transition from a spot fire to a more extensive event easier. If you think "divisions" from the start, you don't have to implement them when the situation is deteriorating; you want to be proactive and stay ahead of the fire.

Think beyond the present situation.

Managing an expanding situation - If the fire isn't controlled with the first alarm assignment, and additional resources are requested, then by definition it moves into an extended-attack operation. If this occurs, adjust your plan and order the appropriate firefighting resources. One indication that an Incident Commander does not have a plan is that orders for equipment "trickle in" to dispatch.

Transition of command - As the incident grows, the initial attack Incident Commander may be replaced by a higher ranking officer. When the fire situation is clearly exceeding his/her comfort zone, the initial attack Incident Commander should prepare for the transfer of command to a new Incident Commander. Under no circumstances is the initial attack Incident Commander to stop running the fire and wait for a replacement to show up. He or she should actively prepare for the transfer of command to a new Incident Commander.

The transition of command should be so efficient that there is no disruption of the operation.

To provide for a smooth transition of the operation to an extended-attack mode, the initial attack Incident Commander should:

- Establish an Incident Command Post.
- Designate a Staging Area and assign a Staging Area Manager.
- Complete a written briefing package utilizing the ICS 201 or similar form. This briefing package should include a list of all the resources assigned and en route, a map of the fire, and location of deployed resources, an organization chart, and a list of key events to date.
- List the objectives used to order the additional resources. Advise the incoming Incident Commander of your thought processes so that he/she can expand upon them if needed.
- Keep the responding resources and dispatch informed of the status of the fire.

Once the new Incident Commander has been briefed, one more step is needed before the transition is complete. The dispatch center and the troops on the fire should be informed of the change in command.

Common Responsibilities or Actions

When a new IC is in place, all forces should be so informed.

There are common responsibilities and items that all fire officers should be familiar with regardless of their assignment on a fire.

Preparing a personal response kit - All personnel need to maintain a personal response kit that will allow them to respond quickly and to be away from home for a week or 10 days without having to visit a laundry. Some of the items that should be included in the kit are:

- Several changes of clothing (uniforms, underwear, socks, etc.)
- Warm jacket and rain gear.
- Personal toilet items.
- Sleeping bag and maybe a personal tent.
- Medicine, if necessary.
- Money, personal credit cards, etc.
- Personal first aid kit.
- Personal safety gear.

Pack your "out of county" bag early.

Preparing a fire officer kit - Some the items that the fire officer should put into this "response kit" are:

- Agency-specific financial documents (purchase orders, credit cards, etc.).
- Forms kits (unit log sheets, check-in forms, vehicle activity, injury/accident reports, timekeeping records, staffing/equipment information sheets, etc.).
- Maps.
- Portable fire radio and spare batteries (enough for 48 hours of operation).
- Field Operations Guide or other agency-specific tactical guides.
- Notebook, pencils, pads, and other miscellaneous office supplies.
- Phone directory.

Being assigned to an incident - When your dispatch office notifies you that you have been assigned to an incident, be sure that you receive the following information:

- Order number and request number.
- Specific assignment.
- Situation status (Type of incident and its status).
- Travel route or any special instructions.
- Communications frequencies (during travel and at the incident).
- Reporting instructions (location and time).
- Resource designation to be used.
- Response mode (immediate, planned, etc.).
- Telephone numbers or other contact information.

Be sure that you know when and where you are to report.

At this point, the fire officer should begin keeping a Unit Log, documenting all the pertinent information and recording key actions and events.

Checking in at an incident - Everybody assigned to an incident has a responsibility to check in when they arrive at the incident. The check-in can be accomplished at one of five locations on an established incident. They are:

- Incident Base with the Check-In Recorder.
- Incident Command Post with the Resource Unit Leader.
- Staging Area with the Check-In Recorder or the Staging Area Manager.
- Helibase with the Check-In Recorder or the Helibase Manager.
- On the fireground with the Division/Group Supervisor, if assigned to an active division or group.

It is your responsibility to check in when you arrive at the incident.

As previously noted, a fire officer has considerable responsibility for ensuring the safety of assigned personnel and for seeing that they complete the tasks assigned to them. You will experience great satisfaction if you know that you have set a good example, performed your job effectively, treated people fairly, and earned the trust and respect of the personnel assigned to you.

Before your people can have a "passion for safety," you have to have it and consistently reinforce it by your actions. It is one of the most important ways that you can demonstrate your level of professionalism and your personal commitment to the fire service and the people you lead.

If you have any remaining doubts about the things we have discussed (e.g., commitment to safety and training, development of good leadership skills, personal integrity, and fairness), let's briefly review the Butte Fire. Reports on the fire stress that the reason 73 firefighters survived a disastrous "blowup" was because of:

- Well-trained, well-disciplined firefighters who responded promptly to orders by their leaders.
- Experienced leaders who tracked the weather and had a plan on how to react if it became critical.
- Properly prepared safety zones that could be reached by short, easily traversed escape routes.

Before your people can have a "passion for safety," you must have it.

May you never experience this type of situation. However, it could happen on any fire, at any time. Strive to maintain a commitment to excellence and safety at all times (Figure 9.6). **Remember the saying "You may only need your seat belt once, but which once"?**

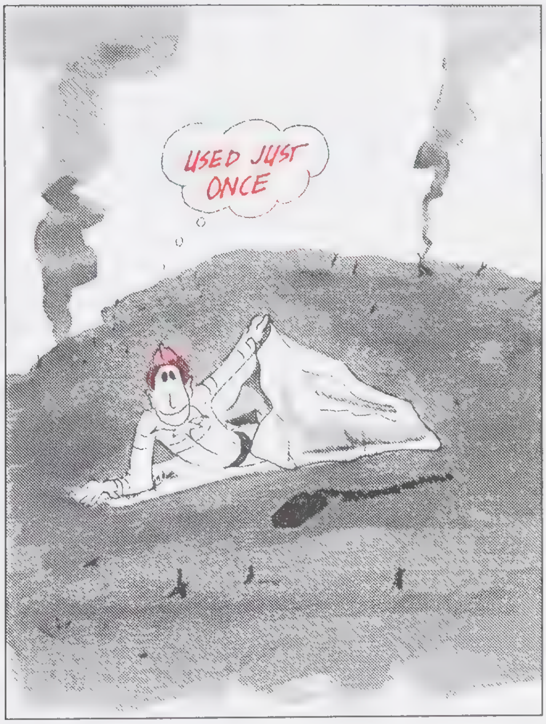


Figure 9.6 You will only need to use your seat belt (or fire shelter) once, but which once?

Notes:

10

Strategy and Tactics

"Whatever the strategy selected, the fundamental principles of fire behavior and fire suppression should always guide decisions that affect the health and welfare of the firefighter." *Art Kukkala and Ted Putman, in Forest Fire Shelters Save Lives, Butte Fire Shelter Deployment Information.*

This chapter will review how to apply the knowledge you have learned in the previous chapters. You will begin to get a feel for the "big picture" and the need for you, as a fire officer, to think strategically.

In this chapter, you'll

- *Learn how to size up an incident and develop a plan.*
- *Gain an appreciation for the importance of tracking the weather.*
- *Learn how to effectively use engines, aircraft, and other resources.*
- *Understand the need to effectively organize an incident.*
- *Learn how to transition from an initial attack organization to an efficient management structure under ICS.*
- *Learn to look at the "big picture."*

It's the Weather, Stupid!

Is there any doubt in your mind that you will be fighting not just a fire, but a fire driven and influenced by the weather (Figure 10.1)? When you consider the influences of weather, you need to be thinking in terms of past, present, and future. How will the weather conditions of the last few hours or days contribute to the spread of the fire? What kind of impact is weather having now? What impact will it have over the duration of the fire? In addition, a post-fire analysis of what occurred and why, and how it was affected by weather, will enhance your strategic thinking skills.

- **At the start of each day**, a fire officer should routinely assess the weather conditions and compare them to what has been predicted. Discuss the potential fire weather for the day with your crew, supervisor, and dispatch office. With experience, you will develop an instinct for what to expect, including a localized sense for the prediction and how it relates to your "first-in area." Weather forecasters use

Changing weather should not be underestimated!

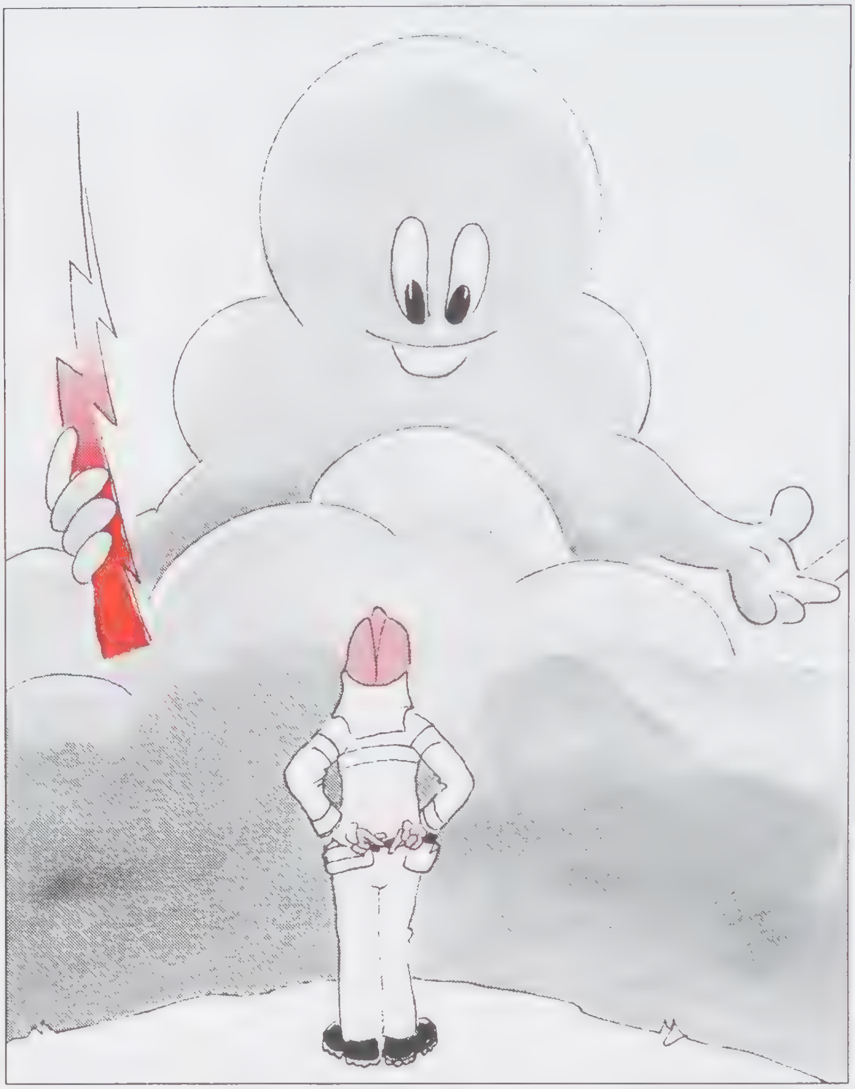


Figure 10.1 It's the weather, stupid!

You may have to fine tune the weather forecast to your area.

specific sites to develop their general predictions. Your local area may be influenced by a lake, the shadow of a mountain range, or have other variables that the weather forecasts do not take into consideration. Take the forecast and compare it to the actual weather in your area. Develop a set of corrections that fine tune the forecast for you. For instance, you may find that a forecast is usually 3° higher in temperature and is 5% lower in relative humidity than is generally true for your area. Use this information to adjust your forecast. If you are in an area you are unfamiliar with, you should discuss the forecast with a knowledgeable local to get a clearer idea of what the forecast may mean in that area (Figure 10.2).

- **En route to a fire**, review the forecasted weather and what you see as you approach the fire. Try to detect subtle differences from what you expected to see. Is there more spotting than you anticipated? Is the smoke column sheared when the winds were predicted to be light and variable? Is the fire making good runs in the grass when the relative humidity was predicted to be over 40%?

Figure 10.2 This fire officer is adjusting the forecast to match local conditions.

Does the weather forecast match what you see on the fire?

- **During the fire**, take the weather at least every two hours. Record the temperature, wind speed and direction, and relative humidity. Make a note as to the general state of the weather, stability indicators, the flame length, and fire behavior. Keep your crew informed of the status of the weather. If you begin to detect a change in conditions, make sure that you inform your crew and your supervisor (Figure 10.3).
- **After the fire**, review your notes and analyze how the weather actually affected fire behavior and the fire suppression effort. Were there any surprises? If so, what caused them and how can you prevent similar surprises?

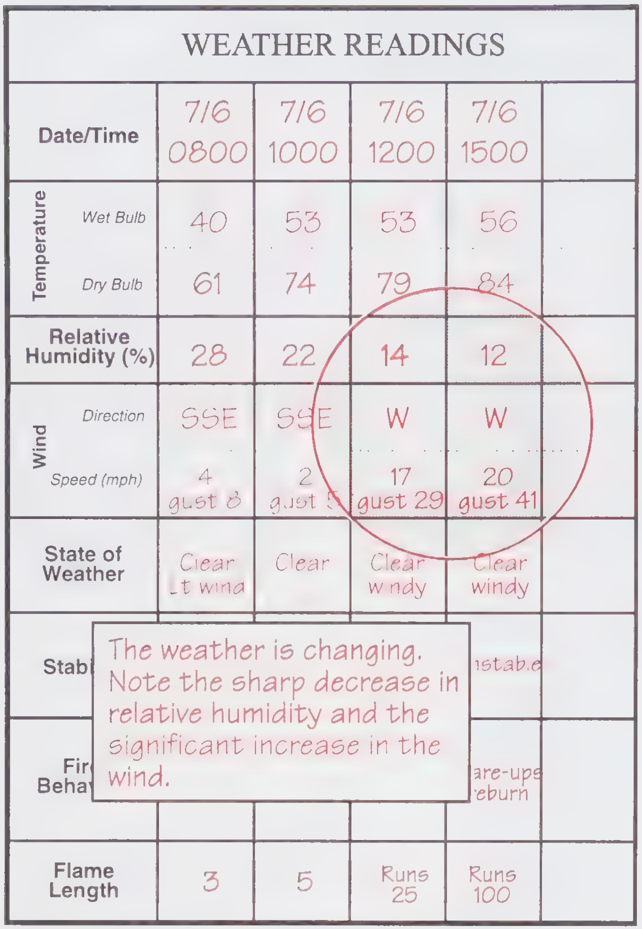
Take the weather and record the information.

If you make an effort to track the weather, you will begin to develop a feel for it, and how and why it is affecting the fire.

Develop a feel for the weather and how it will affect your fire.

Situation Status

You have just been dispatched to a wildland fire. You will be the first arriving fire officer and thus the Incident Commander. You will have to put all of your training and experience together to develop a plan and organization that will control the fire in a safe, efficient, and effective manner.



WEATHER READINGS						
Date/Time		7/6 0800	7/6 1000	7/6 1200	7/6 1500	
Temperature	Wet Bulb	40	53	53	56	
	Dry Bulb	61	74	79	84	
Relative Humidity (%)		28	22	14	12	
Wind	Direction	SSE	SSE	W	W	
	Speed (mph)	4 gust 8	2 gust 5	17 gust 29	20 gust 41	
State of Weather		Clear Lt wind	Clear	Clear windy	Clear windy	
Stabi					stable	
Fir Behav					are-ups eburn	
Flame Length		3	5	Runs 25	Runs 100	

The weather is changing. Note the sharp decrease in relative humidity and the significant increase in the wind.

Weather data from Rifle, CO RAWS Wednesday, July 6, 1994

Figure 10.3 Take and record weather readings.

Your first responsibility is to determine the extent of the fire and what it will take to control it. This chapter will help you select the appropriate strategy and tactics. There is always more than one way to attack a fire—your job is to try to select the right one for the time, date, and place, taking into consideration the firefighting resources you have available. But you should always remain flexible, willing to change your plan in response to changing conditions.

It will be impossible to develop a meaningful, logical plan of attack if you don't know what you are attacking. Start by conducting the best initial size up you can (Figure 10.4)!

Size Up

It cannot be overstated; size up is one of the most important elements of a proper initial attack on a fire. If you don't take the time to get an accurate picture of what is happening, you will not be able to develop an effective plan.

Size up begins when you wake up in the morning and check the weather. This will give you some idea what the burning conditions will be like. If local weather stations are reporting above normal temperatures and winds, and below normal relative humidity readings, you may be in for a challenging day. If most of the initial attack forces in the area are unavailable because they are committed to existing fires, be aware that you may need to deal with resource limitations.

Size up begins well before the fire starts.

Continue your size up while en route to the fire. What does the smoke column look like? It can tell you a lot about the fire (e.g., is it sheared, indicating strong winds aloft?). There are some fires that you know will be a disaster even before you arrive. The weather and fuels are right, and the smoke column you see on the horizon indicates the fire behavior may be extreme.

As you arrive in the area of the fire, you should start developing a detailed analysis of the situation. Analyze what you see, draw conclusions, and develop a plan.

Constantly evaluate your situation and react appropriately. Some of the questions that you should be asking are:

- **What is the fire behavior and rate-of-spread?** Draw some conclusions about how the fire is burning. Is it burning with such intensity that a direct attack will not be safe and effective? Is the fire spotting, crowning, or just smoldering? Determining the flame length and intensity is critical; it will dictate the strategy and tactics. Consider the time of day in the determination of present and anticipated fire behavior.
- **Are there any special safety hazards?** Are there downed power lines? Other common hazards are rolling rocks, automobile traffic, fleeing evacuees, narrow roads, and other access problems.
- **What is the time of day/year?** Is it summer or winter, day or night? Not only will the time of year indicate such things as fuel status, but it will give you an idea whether more people than usual may be in the area (summer cabin users, vacationers, etc.). Time of day will tell you where you are with respect to the peak burning period.
- **Is the fire spotting?** Low humidities, low fuel moisture, and wind contribute to the potential for spotting. Spotting must be factored into your plan. Consider not only whether or not the fire is spotting, but also how far it is spotting and the potential for those firebrands to ignite other fuels.
- **What is the size of the fire?** Estimating the size of the fire provides an indication of its complexity. It also gives your dispatch center an idea of the situation and what resources may be needed.
- **Where did the fire start?** Is the cause obvious? Be sure to make a sketch or mental note of where the fire is when you first see it.
- **What are the weather conditions?** Is there a wind? What is its direction and speed? Is it gusting or constantly chang-

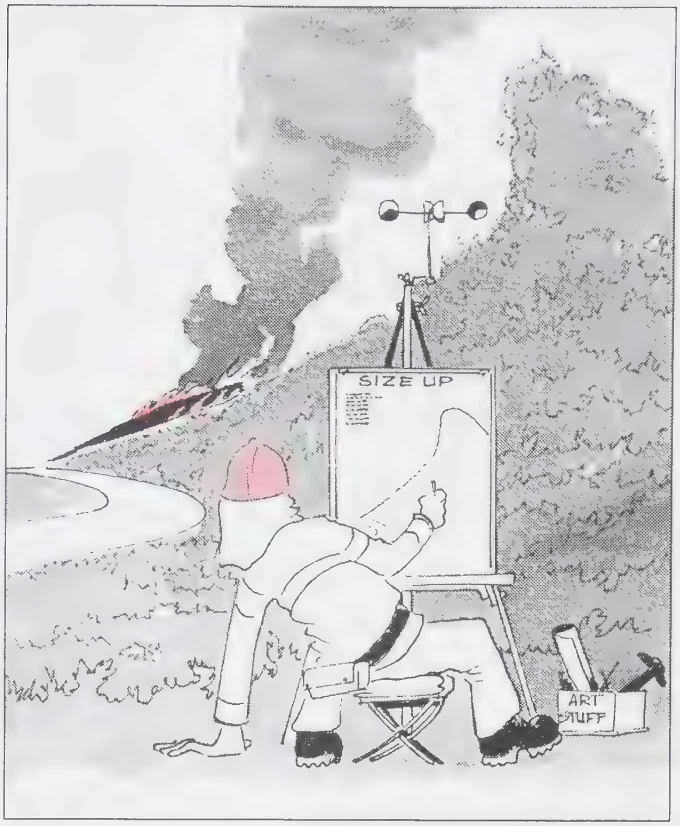


Figure 10.4 This fire officer is beginning to "paint a picture" of the fire.

Paint a picture of what you see happening.

ing direction? Is the wind upslope, across slope, or downslope? Is this a local wind or a general airflow across the area? Does it differ from what was predicted? What is the relative humidity? Is the air stable? Are there clouds, and what do they indicate regarding current and future fire behavior?

How will the terrain affect the fire and your efforts to control it?

- **What is the topography?** Is the lay of the land flat, steep, rocky, or broken up with canyons? Topography influences how the fire spreads and how easily firefighters will be able to traverse it. The steeper the terrain, the harder it will be to fight the fire.
- **What are the fuel types?** Is the fire burning in grass, brush, woodland, timber, logging slash, or tundra? Note the age, loading, dead-to-live ratio, and arrangement. What fuels are ahead of the fire? These are major considerations in developing your strategies and tactics.
- **Are structures or high-value areas being (or going to be) threatened?** What is the potential for the loss of homes, high-value timber, or plantations? Do the structures being threatened have defensible space? Do they have flammable roofs? The presence of high-value areas may cause you to modify your strategy and tactics. It may also change the level of response—more firefighting resources may be required. There is a more detailed discussion on sizing up threatened structures later in this chapter.

Are there structures or other high-value areas to protect?

- **Are there natural or existing barriers?** Are there roads, streams, lakes, or other barriers that can be used as fireline? Use existing barriers when you can. It may reduce the amount of work you will have to do, and it reduces the environmental impact on the land.
- **What is the fire's potential?** Make an effort to predict where the fire will be in 30 minutes, 1 hour, 2 hours, etc. This will help you to develop your strategy. If you predict the fire to be at Road "X" in two hours and that is where you want to stop it, be sure you will have the appropriate firefighting resources to meet that objective. If you don't, change your strategy! Estimate in your mind when you think the fire will be contained and controlled.

Where will the fire be hours from now?

- **Whose land is threatened?** If the fire is burning on lands owned by a large private landowner, notification may be important. Large landowners may be able to provide equipment to help fight the fire. If the fire is burning on the lands of an agency with a modified suppression policy, this will impact how you fight the fire. Modified suppression policies are rules developed by agencies to guide the actions firefighters may take in controlling a fire. The rules are intended to reduce the impact of firefighting on the land. This is of special concern in wilderness areas, national parks, or on lands of historic significance.

- **What should you communicate to dispatch?** The size up should be passed on to your dispatch center so that the dispatchers can use the information to plan their next actions. Give them some information as soon as you arrive. Make it brief, but meaningful. As soon as you have developed more information, relay that to them.

Communicate your size up and plan to dispatch.

One of the first things you should attempt to assess is whether structures are threatened and how that will influence your general plan of attack. If the threat is serious, you may have to abandon all attempts at perimeter attack and just protect life and property. Some of the factors to consider when structures are threatened are:

If structures are involved, your plan will have to accommodate the threat to them.

- **Safety or rescue problems.** Is an evacuation of residents and animals necessary? Some other hazards associated with rural homes are chemicals, septic tanks, and LPG tanks.
- **Number, arrangement and kind.** Look at the placement of the structures and anticipate what the fire behavior will be as the fire approaches them.
- **Size, height and occupancy type.** Are any of these factors going to pose any special problems?
- **Construction.** Are the roof and siding flammable? Are there decks, exposed eaves, open vents, and rain gutters full of dry leaves or needles?
- **Topography.** Where do the structures lay in relationship to slopes and canyons?
- **Access.** Can you get in and out of the area easily? Can the bridges support heavy equipment? Are the roadways clear of brush, or is there flammable material right up to the edge?
- **Type and condition of the fuels.** Do the fuels pose any special problem in the protection of the structures? Is there proper clearance?
- **Water.** Do you have a water supply that is readily accessible and sufficient enough to protect the homes?
- **Timing.** Is there time to clear or fire out around the structures to make their defense easier? Do you have the necessary resources?

Can you get in and out of an area safely?

To develop an accurate size up, you may have to scout the fire. Walk the perimeter, or move to a vantage point to get an overall picture. On a small fire you may be able to see the whole fire as you go "on scene."

You should use your belt weather kit to take the weather on the fireline. Record the various readings so that you can refer to them later on. Take the time to plot the fire on a topographic map. Both of these actions will aid you in planning and establishing a "baseline" record.

If you don't take the weather on the fire you are in violation of the Fire Orders.

Pre-Fire Plans

Structural firefighters have been pre-planning large complex structures for years. Pre-planning provides an opportunity for firefighters to see the building before it is burned and filled with smoke. The plans include vital information on access, construction, built-in fire protection measures, water supply, etc. Do you have a pre-plan for the wildland areas in your first-in area? These plans should be developed jointly with those who have jurisdiction and will be involved with the actual firefight. If you do have pre-plans, be sure to review them as part of your size up.

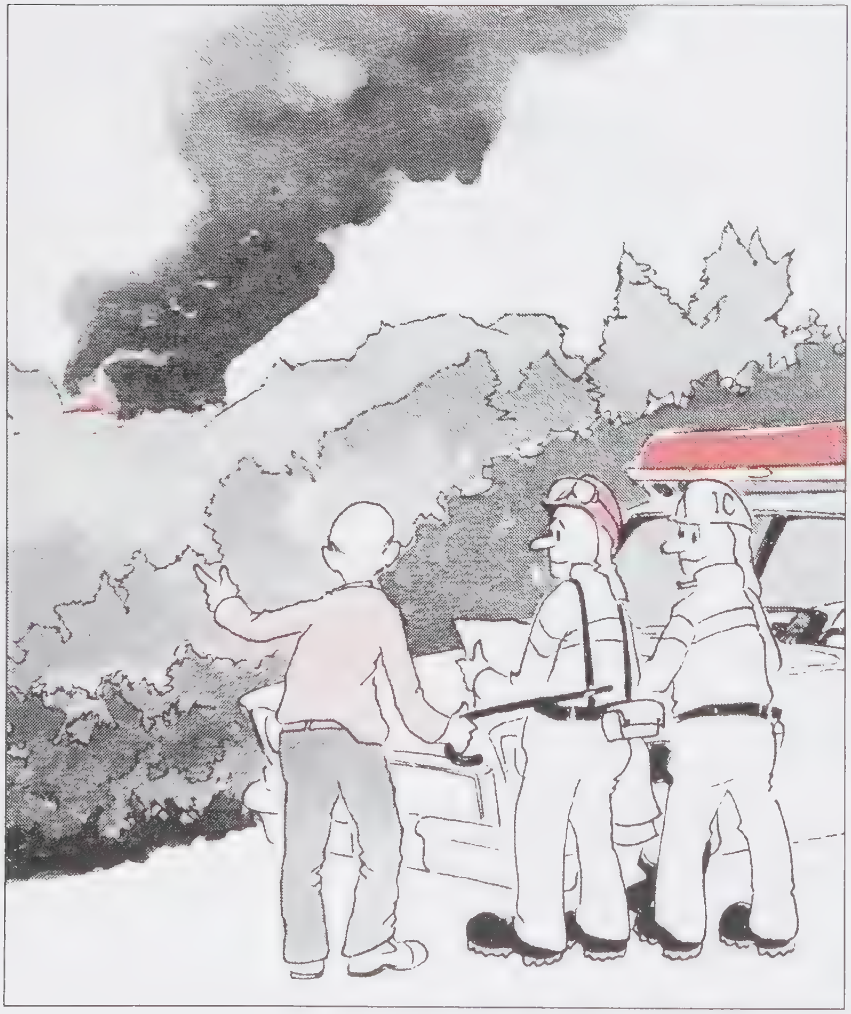


Figure 10.5 This "old timer" has been here before. He may appear to be a prophet, but he was on "this fire" the last time it burned.

Fire History

Knowing how the last fire in this area burned can be very valuable information. Wildland fires tend to follow historic patterns under similar weather conditions. If a fire has burned in the area before, try to get some information about the previous fire (Figure 10.5).

Many departments maintain fire history information. Use it if you can.

Need for a Map

Begin to plot the fire on a map. You would be unwise to begin a long trip in unfamiliar country without a road map (Figure 10.6). The same thing is true when attacking a wildland fire. Maps provide a way for you to visualize where you are going and what is the best and most effective way to get there. It is your two-dimensional view of reality. Your map provides a way to plot the progress of the fire, your fire behavior predictions, access, the location of any special hazards, and the placement of your resources.

If you don't have a map you are at a serious disadvantage.

Figure 10.6 This fire officer doesn't have a map and has no idea where she is going. This is not a good situation to be in!

The best type of map is a 7.5-minute topographic map (Figure 10.7). It has a useful scale and provides a good picture of the lay of the land. If you don't have this kind of map available to you, do the best you can, even if you just sketch some general features on a piece of paper (Figure 10.8).

The best map for wildland firefighters is a topographic map.

Fire Behavior Prediction

Before you can develop your plan of attack, you have to give some thought to what the fire is going to do over the next several hours. Estimate when the fire will arrive at certain points; plot them on your map. You do this to give yourself benchmarks against which to evaluate the progress of your planned strategy.

Estimate where the fire will be and plot it on your map.

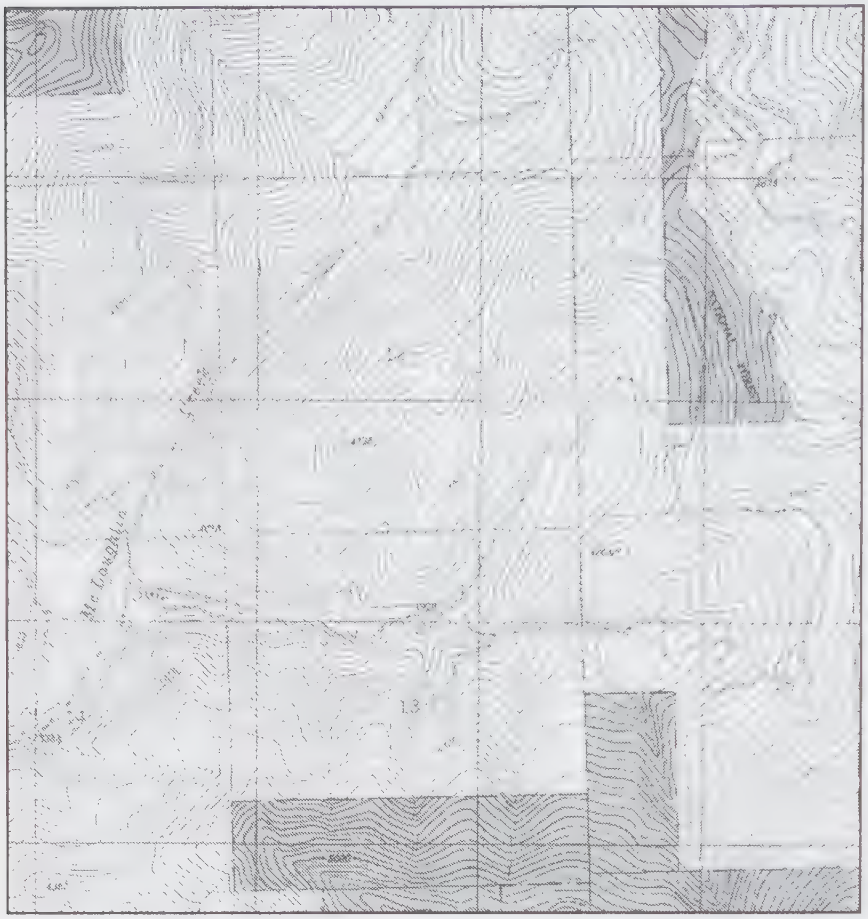


Figure 10.7 The best map for wildland firefighting is the 7.5-minute topographic map. It provides an excellent place to plot the fire, your predictions, etc.

Topographic maps provide a "third dimension".

Only after you estimate where the fire will be, can you realistically develop a plan to fight it.

In developing your fire behavior predictions, you can use several methods: the nomograms discussed in Chapter 4, the services of a fire behavior analyst, or simply a best guess. **The method you employ is not as important as the fact that you attempt to predict when the fire will be at a certain location.** Only in this way will you be able to develop a sense for what you are up against and the timing of your attack.

Developing a Strategy and Plan of Attack

Now you have developed a feel for the situation through your size up and fire behavior prediction. Your first decision is whether the situation dictates you take offensive or defensive actions (Figure 10.9).

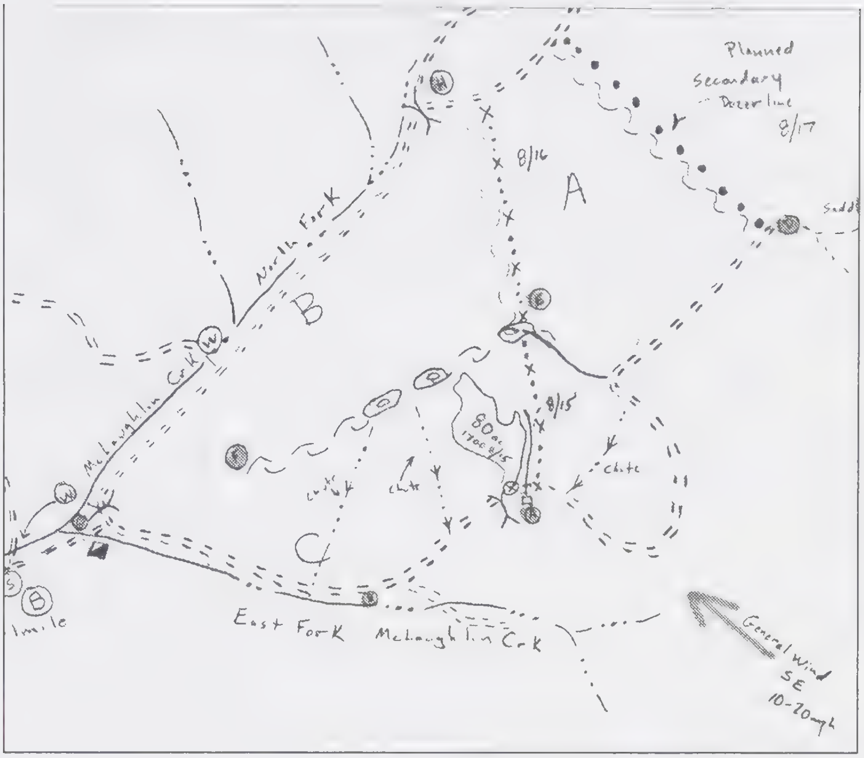

Planned
Secondary
Dozer line
8/17
8/16
A
Sadd
North Fork
B
McLaughlin Crk
80ac
1700 8/15
8/15
chute
chute
chute
C
S
B
1 mile
East Fork McLaughlin Crk
General Wind
SE
10-20mph

Figure 10.8 If all you have is a blank piece of paper, plot your fire on it. At least it provides a visual reference from which to work.

If you don't have a map, draw one!

- **Offensive Action** - An offensive attack is one that confines and controls the fire by constructing fireline. Protection of structures may be required, but the majority of the fire suppression effort is focused on line construction. Before deciding on an offensive action, you must be certain that your people can implement it safely, and you must have ample resources available. An offensive action can utilize direct or indirect attack strategies. In structural firefighting, an offensive action is usually an interior attack.
- **Defensive Action** - A defensive action is taken when the fire behavior is such that an offensive action

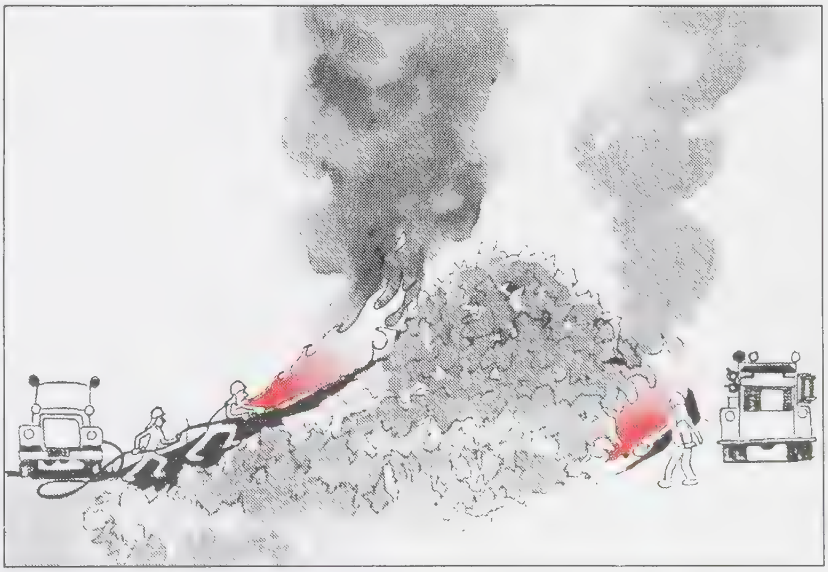


Figure 10.9 There are considerable differences between offensive and defensive actions. Don't mix them. Know exactly which mode you are in.

is too dangerous. You might also have to take defensive positions if there are limited firefighting resources, or if the resources are focused on protecting life, property, or high-value natural resources. In most cases, a defensive action is taken to minimize the damage, not contain the fire. **In a defensive action to protect structures, the moving fire controls the action**. In structural firefighting, a defensive action is usually an exterior attack.

When you are in a defensive mode, the fire controls your action.

There will be cases where the attack mode on one division may be defensive, but the rest of the fire is being attacked using various offensive actions. As noted, it is very important that you know which mode you are in—you don't want to mix modes without giving it some real thought.

Establishing a Goal and Objectives

As you prepare your plan of attack, you should write down several simple objectives for what you will be attempting to do. Of course, if the fire is a spot of grass and you can put it out with 50 gallons of water or less, this step isn't necessary. But let's say the incident is a little more complicated. You can't see all of the fire, aircraft are en route, and structures may be threatened. This is when you should outline your plan, not just for you, but for the other firefighters on the incident.

Life safety is your first priority.

Operations may vary in size, but the overall priorities stay the same. The four general priorities are:

- **Life safety** - The protection of human life is always the first priority. This includes the lives of firefighters.
- **Property protection** - The protection of structures is usually the next priority. In some jurisdictions, the protection of property and resources are grouped.
- **Resource protection** - The protection of natural resources, timber, plantations, etc., is generally the next priority.
- **Incident stabilization** - This priority deals with the organization that is developed to ultimately control the incident.

Develop your objectives.

After developing your plan, develop the strategic goals for the incident. These are broad statements that describe major actions. **They don't necessarily state how you plan on attacking the fire, but what you plan to do, or what you want to accomplish.** Keep the objectives or the strategic goals simple:

"Keep the fire from crossing Duncan Hill Road" or "Protect the structures along Penny Lane." Develop a list of objectives that encompass all of the fire.

Escape Routes and Safety Zones

It is fairly easy to define an escape route. It is a route of travel known to everyone on a fire that leads away from a point of danger, generally to a safety zone. Escape routes must be easily traveled, e.g., not usually uphill, not too far from the nearest safety zone, and situated such that everyone can reach them quickly. Multiple escape routes may be needed depending on the size of the fire and where people are working.

Escape routes must be easy to use.

Safety zones are a little more complicated. A safety zone is generally defined as a pre-planned location of sufficient size and suitable location that it can be expected to protect fire personnel from known hazards without the use of fire shelters. However, the issue of safety zones not requiring the use of fire shelters is complicated by several things. For instance, recommendations regarding the size of the safety zones vary depending on terrain, fuels, fire behavior, and the number of people involved. Thus, if you're fighting fire in timber, a properly constructed safety zone can take a considerable area.

An adequate safety zone is a place where you can survive without the use of a fire shelter.

As a general rule, the safety zone should include about 50 square feet per person, with an additional cleared space on all sides of the deployment area equal to 4 times the height of the fuel (Figure 10.10). 50 square feet per person (6 by 8 feet) allows enough room for firefighters to deploy their shelters if it becomes necessary.

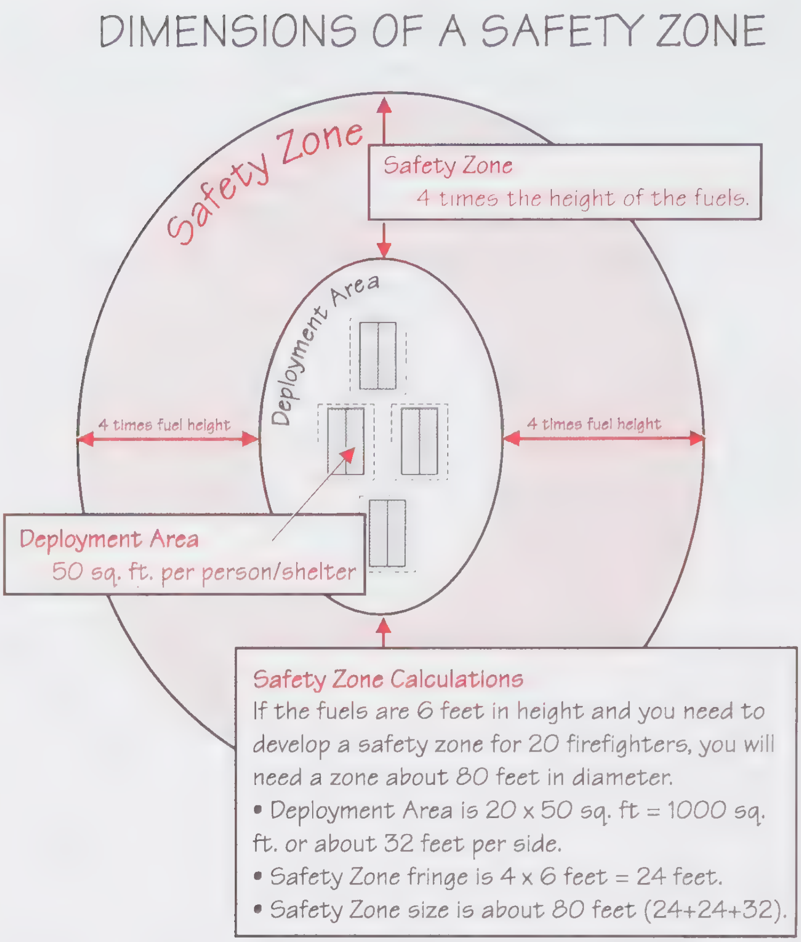
On the Butte Fire, 73 firefighters deployed their shelters. The area needed would have been 8.9 acres. This size safety zone is impractical to construct. So what do you do when you are working in areas with no natural safety zones of the size you need?

The size of a safety zone is dictated by the height of the adjacent fuels, topography and predicted fire behavior.

There are several things that you can do:

- Construct fireline in another area, where the fuels are not as tall.
- Work the line only when the fire behavior will not be a problem.
- Use a direct attack, using the "black" as your safety zone—

The general rule is to have 50 square feet of area for each firefighter.


DIMENSIONS OF A SAFETY ZONE
Safety Zone
Safety Zone
4 times the height of the fuels.
Deployment Area
4 times fuel height
4 times fuel height
Deployment Area
50 sq. ft. per person/shelter

Safety Zone Calculations

If the fuels are 6 feet in height and you need to develop a safety zone for 20 firefighters, you will need a zone about 80 feet in diameter.

- Deployment Area is 20 x 50 sq. ft = 1000 sq. ft. or about 32 feet per side.
- Safety Zone fringe is 4 x 6 feet = 24 feet.
- Safety Zone size is about 80 feet (24+24+32).

Figure 10.10 Calculating the size of a safety zone.

assuming that it is cleanly burned and there is no chance of a reburn.

Balance the risk with the benefit.

In all cases, you must weigh the risk of what you want to do against the potential benefits; the safety of firefighters must be given primary consideration (Figure 10.11).

BENEFIT
RISK

Figure 10.11 You must always weigh the risk of your actions against the benefits. If the benefits don't outweigh the risks, change your plans.

Line Placement and Construction

In wildland firefighting, the construction of fireline is your primary goal. There are sometimes other critical considerations, like saving lives and property, but ultimately, constructing and holding line is your primary mission. Selecting where you will build fireline may be as simple as using roads, trails, or other existing barriers. Or it may be quite complicated, such as when you have to deal with heavy fuels, steep topography, or certain land use restrictions (like in a wilderness area).

Some of the factors that will influence the type of fireline you use are:

Stay away from heavy fuels if you can.

- **Safety of personnel** - Safety is not limited to such concerns as downhill fireline construction or working below bulldozers; it also involves the qualifications of the personnel who will be used to construct fireline. It probably would not be wise to use firefighters from a large metropolitan department to construct hand line, in an attempt to pinch off a fast moving brush fire; this is a task for a highly experienced hotshot or Type 1 crew.
- **Values at risk** - The value of what is being threatened by the fire has a significant influence on where and when you will construct fireline. If a fire is moving toward homes, you may place a priority on a line to protect them first. The key is to know the values at risk and to prioritize them accordingly.
- **Land use restrictions** - If an area has been designated wilderness, involves archeologically sensitive materials, or if the landowner has special restrictions, you may have to confine yourself to fireline construction methods that have little or no impact on the land. If there are such restrictions in your area, become familiar with them. Use the most effective line construction technique that is allowed under the restrictions. If you feel that you may have to use techniques that are prohibited under the restrictions, ask before you use them! This is one of those areas where you want to ask for permission, rather than forgiveness.
- **Terrain features and access** - You may be restricted from an area by the terrain; it may be too steep for bulldozers or unsafe for handcrews to work. The terrain may be too rocky for a mobile attack with engines. Or the fire may be deep in a narrow canyon where airtankers cannot safely operate (Figure 10.12). Unfavorable terrain features may require your retreat to areas that are more favorable.
- **Availability of resources** - You can't use certain types of firefighting resources if they aren't available. Design your plan around the tools that you will have at hand. If you want to cut line through 20-foot thick slash, and heavy bulldozers will not be available, don't give the task to a handcrew.

Know if there are any land use restrictions that will hamper your line placement.

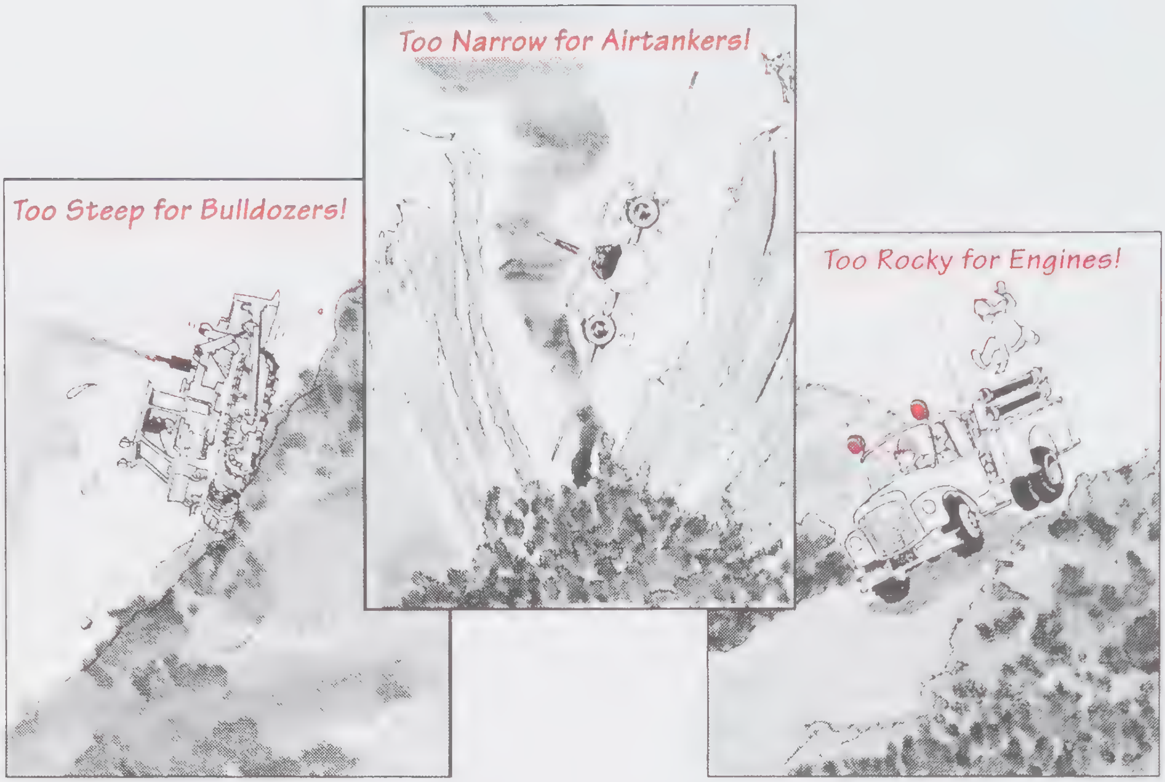

Too Steep for Bulldozers!
Too Narrow for Airtankers!
Too Rocky for Engines!

Figure 10.12 This plan is all wrong. It is too steep for bulldozers, too rocky for engines, and too narrow for airtankers.

- **Fuel type and condition** - It is best to stay away from heavy fuels if you can. If you can't, then be sure that you have the right tools for the task. Know what to expect from certain fuels. If the area has not had a drenching rain for a long time, the fuels may be very dry and explosive. Fuel type and condition dictate the width of the proposed fireline. (See Chapter 3.)
- **Fire behavior** - The level of fire behavior will have a significant influence on where you place your fireline. If the fire is running hard, you will want to place your lines far enough ahead of the fire so that you have adequate time to complete construction. The fire's flame length influences the width of the fireline. (Flame length, and fuel type and condition also relate to a fire's resistance to control.)
- **Speed** - The old saying, "the quickest route between two points is a straight line," may not always apply to firefighting. If this straight line takes you through a snag patch or heavy brush, you will want to go around it. You do want to construct line as fast as possible, but never construct line that you don't plan on holding. It is better to put in one mile of line and hold it than to put in three miles of line and lose it.

Do you have the resources to construct the fireline you are planning?

Now that you have generally decided where you want to take your fireline, there are several principles to consider. These are general rules of construction that will make your job easier and your fireline more effective. The first three principles deal with increasing the ease of fireline construction; the last several principles deal with the ease of holding the fireline. These principles are:

- **Keep the fireline as straight as possible** - Not only is a straight line shorter but it is more effective. Kinks, sharp curves, and bends tend to be points where a fire will escape. However, as noted above, you do want to go around snag patches and heavy fuel.
- **Keep the fireline as close to the fire's edge as practical** - By keeping close to the fire's edge, the final size of the burned area should be smaller. By working close to the fire, you can also use the black for refuge if something unexpected happens.
- **Utilize existing barriers when you can** - If there is an existing road, lake, rock outcropping, meadow, or such that can be used as a fireline, use it. This will not only reduce the amount of work needed, but will also reduce the long term impact of your fire suppression operations on the environment.
- **Ensure that your fireline is anchored** - You should never construct fireline without considering how the line will be anchored. It is unsafe, embarrassing, and downright unprofessional, to have a fire come around your fireline and surprise you from the rear.
- **Include spot fires inside your fireline** - If there are spot fires ahead of the fire, be sure to keep them on the inside of your proposed fireline. Don't develop a plan that will require trying to find and control a lot of individual spot fires if you don't have to.
- **Avoid heavy fuels and snags when possible** - If you can, keep your line construction in light fuels. The fireline will be easier to construct and hold.
- **Plan for the fire's spread** - If you have to construct fireline well ahead of a fire, be sure to allow enough time for both construction and any needed firing operations. Err on the side of having more time than you need. A half-completed fireline is no fireline at all, and a great deal of effort will have been wasted because you didn't plan far enough ahead!

Don't construct fireline you don't plan on holding.

Keep the fireline as straight as possible.

Anchor your fireline.

Include spot fires inside your fireline.

- **Place your fireline at the base of a slope or on the backside of a ridge** - By using the base of a hill or the backside of a ridge, you use topography to your advantage. The slope will aid in any burning you have to do and will reduce the potential for escape if the fire is allowed to burn up to the constructed fireline.

Use the topography to your advantage.

Now that you have decided where to construct your fireline, there are several basic techniques to make fireline construction more effective:

- Cast all charred or burned fuels to the inside of the fireline.
- Cast all unburned fuel either inside the fireline to assist in the burnout or outside the fireline to reduce the hazard, depending on which is most appropriate for the situation.
- Reduce the amount of aerial fuels before control lines are fired. Fell nearby snags when possible.
- If working on firelines mid-slope, trench the fireline to catch rolling material.
- Cool flare-ups or hotspots near the fireline to reduce the potential for escape.
- Do not bury burning material. Put it out or move it away from the fireline, and allow it to burn out.
- Don't build any more fireline than you have to. Match the width of the fireline to the terrain, weather, fuel type, and fire behavior. As a rule of thumb, the minimum width of the fireline should be 1½ times the height of the fuel.
- Reinforcement of the fireline with a hoselay (water) or retardant drops may be needed.

Cast all charred fuels toward the fire.

Don't build more fireline than you need.

As a fire officer, you will be responsible for checking that the fireline has been constructed properly. The following is a list of items that you should check for:

- Is it in the best location?
- Were the ladder fuels removed?
- If trenching was needed, was it done properly?
- Are there any snags in the area that should be felled?
- Has the fire burned to the line cleanly? If not, will the line need to be burned out or cold trailed?
- Are there any spot fires? If so, have they been properly dealt with?
- Do all of the lines tie together? If not, how and when will this be accomplished?

- Once the fire is controlled, will the line have to be reworked, waterbarred, or generally cleaned up and rehabilitated?
- Is there trash that was left behind by the firefighters? When will it be cleaned up?

Be sure all of your firelines tie together.

Mop-Up and Patrol

All too often, a fire escapes because the fire was not properly mopped-up and patrolled. Mop-up is the really dirty, boring part of wildland firefighting. But it must be done. If time and circumstances allow, let the fuels burn up completely.

The first priority in mopping-up should be to find and control spot fires. The next priority should be to control hotspots close to the fireline or unburned pockets of fuel within the fireline. If there is an unburned island near the fireline, treat the edge of this island as if it were perimeter fireline. Many a fire has been lost when an unburned island ignited and threw burning material across firelines. Don't let it happen to you (Figure 10.13).

Move along the fireline, clearing away unburned fuels that are near hot fuels. Cool hotspots with water or by mixing them with soil using a shovel or other hand tool. Arrange heavy fuels so that they will not roll across the line.

The final mop-up process should involve a systematic search of the area. Move through an area as if it is covered by a grid. Don't forget to look at every inch of the area you are responsible for mopping-up.

Spot Fires Take a Priority.

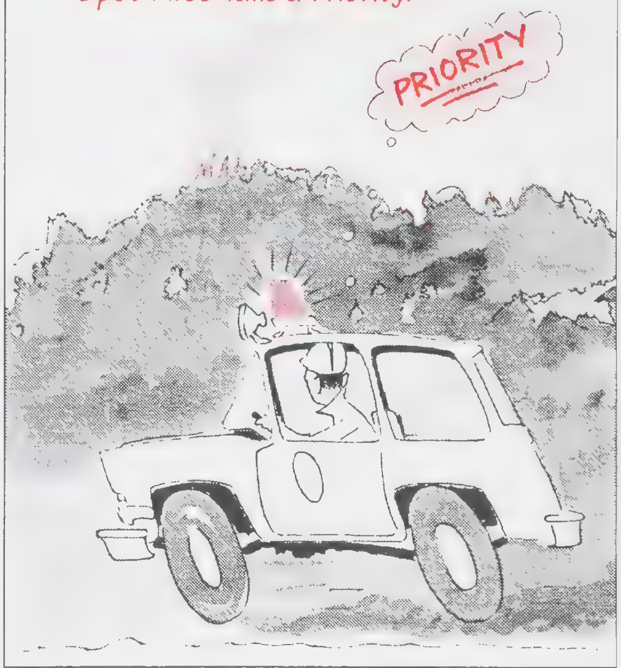


Figure 10.13 The priorities for mop-up are finding and controlling spot fires, cooling hotspots, and containing unburned islands.

Minimum Impact Suppression Tactics

The goal of minimum impact suppression tactics is to use the minimum amount of force necessary to contain and control the fire, consistent with the law and the agency's policies and procedures. At one time, the primary objective of a firefighter, after life safety, was putting the fire out, even if the suppression actions did more long-term damage to the land than the fire itself. This was justified by the desire to keep all fires small. But times have changed, and it is no longer correct to fight fire this way.

Spot fires are a priority.

As a fire officer, you are responsible for the suppression of fires in the most expedient and prudent manner possible. You have to consider the long-term effects of your actions and modify your plan accordingly. To some, this appears to be counterproductive. You may hear comments like, "What do you mean I can't use my bulldozer to cut that line!" or "Why can't I cut down that snag; it's a safety hazard—let the '*blank*' bird nest somewhere else!" Firefighters are sometimes known for their "bullheadedness," and unwillingness to take "orders" from an "ologist." But these are the new rules, and they must be complied with. (See Appendix 1 for a brief description of the various federal laws pertaining to the protection of the environment and historic artifacts.) It goes without saying, however, that the safety of your people takes priority over everything else (Figure 10.14).

Don't do more damage to the environment than absolutely necessary.

The single most destructive tool in your firefighting arsenal is the bulldozer. It is also one of the most productive line building tools. But using a bulldozer isn't the only activity that can cause damage to the land. You can damage an area by just walking along the same path over and over. Small "scratch lines" used as control lines can become gullies if not properly cared for. Your goal, although it may be difficult to attain, is to leave an area better and cleaner than it was when you arrived.

The bulldozer can cause extensive damage. Use it wisely.

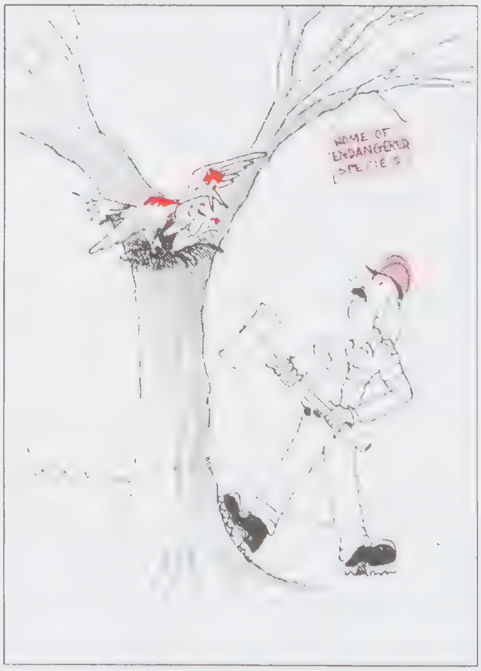


Figure 10.14 This "bird" knows her rights. In some areas the snag will have to be left standing.

The intent of the following guidelines is not to present a whole new set of firefighting tactics. They are meant to be used as you would use traditional suppression methods. The goal is to minimize the long-term impact on the environment and historic relics, and still put out the fire as safely and efficiently as possible. The following are some minimum impact suppression tactics guidelines, grouped by type of operation:

There may be times that special minimum impact rules are appropriate.

Hot fireline involving ground fuels

- Allow fire to burn to natural barriers.
- Use cold trail, wet line, or a combination of both as appropriate.
- If constructed fireline is necessary, use only the width and depth necessary to stop the fire.
- Burn out and use low impact tools whenever possible.
- Minimize bucking and cutting of trees to establish fireline; build line around logs when possible.
- Use rubber-tired equipment rather than tracked vehicles when possible.
- Constantly re-check cold trailed fireline.

Use natural barriers when you can.

Hot fireline involving aerial fuels

- Limb vegetation close to the fireline only as needed to prevent additional fire spread.
- During fireline construction, cut shrubs or small trees only when necessary. Make all cuts flush with the ground.
- Minimize felling of trees and snags unless they threaten fireline or seriously endanger firefighters. In lieu of felling, identify hazardous trees with a lookout or by flagging.
- Scrape around tree bases near fireline if it is likely they will ignite.

Fell only those trees or snags that threaten fireline.

Mop-up operations involving ground fuels

- Do minimal spading; restrict spading to hot areas near fireline.
- Cold trail charred logs near fireline; do minimal tool scarring.
- Minimize bucking of logs to extinguish fire or to check for hotspots; instead roll the logs whenever possible.
- Return logs to original position after checking (once the ground is cool).
- Refrain from making bone yards; burned and partially burned fuels that were moved should be returned to a natural arrangement.

Allow logs to burn out.

- Consider allowing large logs to burn out. Use a lever rather than bucking to manage large logs which must be extinguished.
- Use gravity socks in stream sources and/or a combination of water "fold-a-tanks" to minimize the impact of run off on streams.
- Consider using infrared detection devices along the perimeter to detect hotspots.
- Avoid using rehabilitated firelines as travel corridors whenever possible because of potential soil compaction and detrimental impact to rehab work.

Mop-up operations involving aerial fuels

Identify hazards with flagging.

- Remove or limb only those fuels which if ignited have the potential to spread fire outside the fireline.
- Before felling, consider allowing an ignited tree/snag to burn itself out. Ensure adequate safety measures are communicated to all personnel if this option is chosen.
- Identify hazardous trees with a lookout or by flagging.
- If burning trees/snags pose a serious threat of spreading firebrands, try to extinguish the fire with water or dirt. Felling should be the last resort.
- Align saw cuts to minimize the visual impact from more heavily traveled corridors. Slope the cut away from line of sight when possible, so that it isn't evident that a tree has been removed.

Campsite locations and conduct

Use existing campsites if possible.

- Locate facilities outside of wilderness areas when possible.
- Evaluate short-term low impact camps such as "coyote" or "spike" versus use of longer-term higher impact camps.
- Use existing campsites if possible.
- New site locations should be on impact-resistant and naturally draining areas such as rocky or sandy soils, or openings in the timber.
- Avoid camps in meadows, along streams, or on lake shores. Locate the camp at least 200 feet from lakes, streams, trails, or other sensitive areas.
- Consider the impact on both present and future users. An agency commitment to wilderness values will promote those values to the public.
- Lay out the camp components carefully from the start. Define cooking, sleeping, latrine, and water supply areas and restrictions.
- Minimize the number of trails and ensure adequate marking.

- Consider fabric ground cloth for protection in high-use areas such as around cooking facilities.
- Use commercial portable toilet facilities if possible. If these facilities are not available, a latrine hole should be utilized.
- Select latrine sites a minimum of 200 feet from water sources, with natural screening.
- Do not put nails in trees.
- Constantly evaluate the impact which will occur, both short- and long-term.

Personal camp conduct

- Use "leave no trace" camping techniques.
- Minimize disturbance to land when preparing bedding sites. Do not clear vegetation or cut trenches to create bedding sites.
- Use stoves for cooking when possible. If a campfire is used, limit it to one site and keep it as small as reasonable. Build either a "pit" or "mound" type fire. Avoid the use of rocks to ring fires.
- Use down and dead firewood. Use small diameter wood since it burns down more cleanly.
- Don't burn plastic or aluminum; pack it out with other garbage.
- Keep a clean camp, and store food and garbage so that they are unavailable to bears. Ensure items such as empty food containers are clean and odor-free. Never bury them.
- Select travel routes between camp and the fire, and define the routes clearly.
- Bathe away from lakes and streams. Instead, transport bathing water to an area that is less environmentally sensitive. Do not introduce soaps, shampoos, or other personal grooming chemicals into waterways.

Keep your camp clean.

Air operations and their impact

- Maximize the use of aircraft. Don't let them fly empty, use back haul or return flights as much as possible.
- Use a long-line remote hook in lieu of constructed helispots for delivery or retrieval of supplies and gear.
- Take precautions to ensure noxious weeds are not inadvertently spread through the deployment of cargo nets and other external loads.
- Use natural openings for helispots and paracargo landing zones as far as practicable. If you need to construct helispots and landing zones, avoid high visitor use areas.

Maximize the use of aircraft. Don't let them fly empty.

- Consider maintaining existing helispots rather than creating new sites.
- Obtain specific instructions for appropriate helispot construction prior to the commencement of any ground work.
- Whenever possible, fell trees and snags in a direction that results in the most natural-looking appearance.
- Buck and limb only what is necessary to achieve safe/practical operating space in and around the landing pad area.
- Use retardants only when necessary. Do not use retardants near surface waters.
- Consider using foam rather than retardant whenever possible.

Use retardants only when necessary.

Rehabilitation activities

- Pick up and remove all flagging, garbage, litter, and equipment. Dispose of trash appropriately.
- Clean fire pit of unburned materials, then fill the pit back in.
- Discourage others from using any new trails created during the suppression effort by covering the trails with brush, limbs, small diameter poles, and rotten logs in a naturally appearing arrangement.
- Replace dug-out soil and/or duff, and obliterate any berms created during the suppression effort.
- If trails have developed on slopes greater than 6%, construct waterbars according to Figure 10.15. They should be about 45° to the slope and should open on the outlet end to ensure drainage. Location is critical. Try to locate waterbars so that the outlet drains onto slash, rocks, unburned vegetation, or other materials that dissipate energy and minimize erosion.
- If soil has been compacted, scarify the top 2-4 inches and scatter with needles, twigs, rocks, etc.
- Blend campsites with natural surroundings.
- Flush cut all stumps.
- Leave tops of felled trees attached.
- Remove stumps or dams, where they have been used, and return site to natural conditions.

Waterbar to reduce erosion.

WATERBAR SPACING GUIDE

Trail/Fireline Grade (%)	Maximum Recommended Spacing (feet)
6 to 9	400
10 to 15	200
15 to 25	100
25+	50

Figure 10.15 Waterbar spacing guidelines.

When Structures Are Threatened

The need to protect structures from an advancing wildland fire is becoming more and more common. As discussed previously, the first priority of a fire department is to protect life and property, and firefighting resources sometimes must be diverted from a role of perimeter control to one of protecting structures. As noted, some of the general factors to be evaluated when structures are threatened are number, arrangement, and access. Other more specific factors need to be considered when deciding whether a particular structure can be saved.

You will not usually have enough engines to protect all of the threatened structures.

Structure Triage

On a major wildland fire there are usually not enough engines to attack the spread of the fire and protect every structure threatened by the fire. The decision as to what structures will be protected is based on "sorting" or "prioritizing"—this is called structure triage. When you begin to triage the structures, your goal is to protect and save as many as possible with the firefighting resources you have at hand.

There are those structures that are threatened; those that are not threatened; and those that are lost.

From a triage point of view, there are three types of structures:

- **Those that need little or no attention**. They are constructed of materials that will not normally ignite, and they have proper clearance.
- **Those that need protection**. These structures are constructed of flammable materials and may not have the needed clearance, but with an effort by fire department personnel, they probably can be saved.
- **Those that are lost**. Even though they may not yet be on fire, these structures cannot be saved. They are primarily those structures that are constructed of flammable material and that don't have the proper clearance, or where the ingress/egress is such that it would be dangerous to attempt to protect them. The structures in this category generally have other problems such as wood or debris piles near the structure.

In your effort to select the structures that you have the best chance of saving, you have to consider multiple factors. The primary considerations are as follows:

Structure - How combustible are the roof and siding? What is the pitch of the roof, and how much debris is on top of it? Are there "heat traps" like open gables, unscreened vents, or overhanging decks? Are there large windows that could easily be cracked by the heat of the fire? What is the size and shape of the building? What is its position on the slope? (Figures 10.16 and 10.17)

Leaves are easily ignited by firebrands.

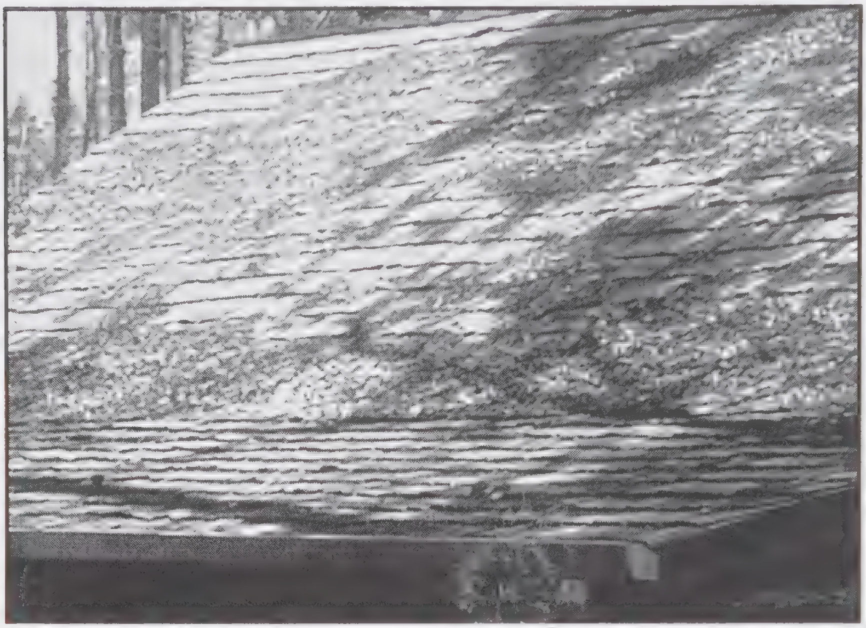


Figure 10.16 Even though the roofing material is Class A, the forest litter on top of the roof will cause problems.

Openings allow the fire to easily enter the structure.

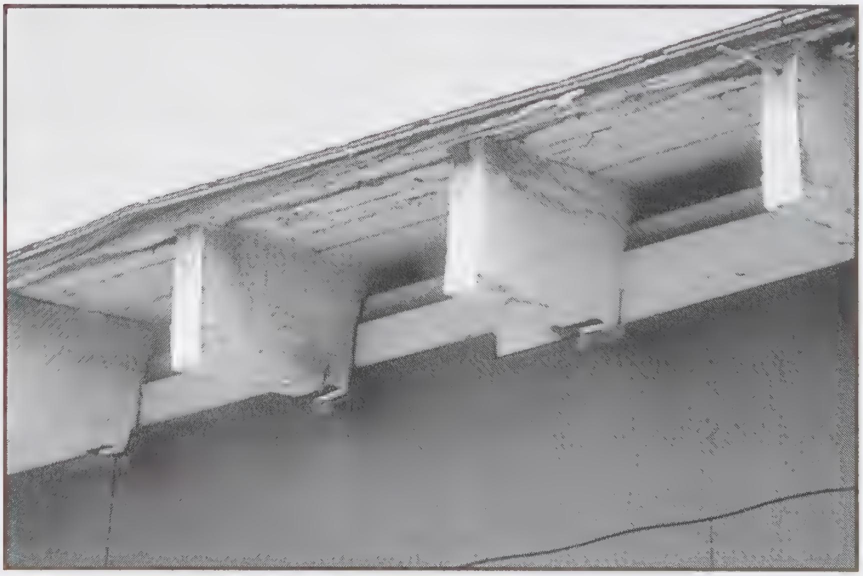


Figure 10.17 These eaves and open vents have a real potential to draw firebrands into them.

Fuels - It is estimated that 90% of the structures that are lost to an advancing wildland fire are lost because of a lack of adequate clearance from flammable fuels. You need to analyze the fuels that are near the structure as well as those fuels that may produce firebrands or radiant heat (Figure 10.18). You should look at the size and arrangement of the fuels, their age, proximity, loading, and type. How long will the fuels burn? What is the landscaping like, and is there defensible space? Is there an accumulation of "junk" or stacked wood in the yard? Are there aboveground fuel tanks that may present a problem? (Figures 10.19 and 10.20).

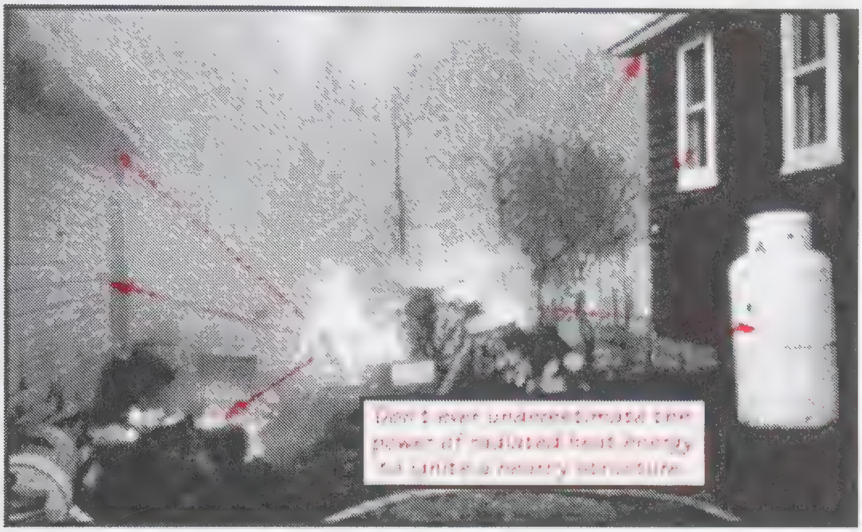

Don't ever underestimate the power of radiated heat energy to ignite a nearby structure.

Figure 10.18 In this case, radiated heat may cause the fire to spread.

Never underestimate the ability of radiated heat to spread the fire.

Some structures are not defendable.

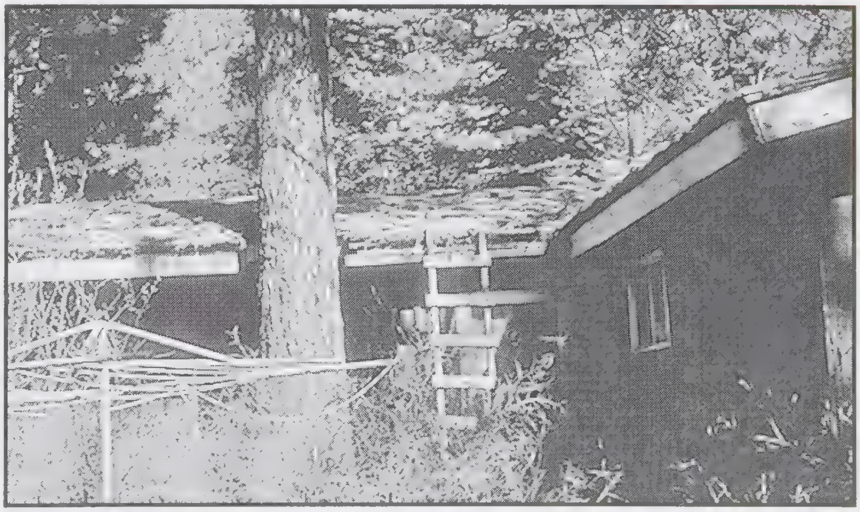


Figure 10.19 This house will be difficult to protect from an advancing wildland fire. Note the lack of any clearance, and the debris on the roof.

Fire Behavior - The level of fire behavior will give you some idea of whether you will be able to protect a structure. If the fire is just creeping through the ground litter, you have a different problem than a situa-

Some structures have good defensible space.

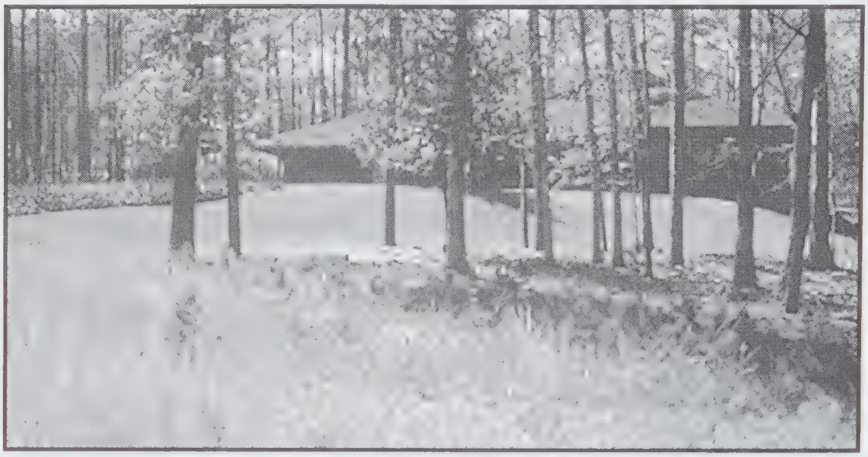


Figure 10.20 This house has defensible space and could possibly survive a wildland fire even with little or no action by firefighters.

tion where the fire is crowning (Figure 10.21). When analyzing the fire behavior, study the rate-of-spread, topographical and weather-related influences, flame length, spotting potential, and timing. Are there any barriers that you may use to your advantage?

Firefighting Resources - What kind of firefighting resources do you have to fight the fire? What are their kind and type? Are the firefighters experienced in this type of firefight? How much water do you have available? How long will it take to get these resources in place and into action?

Firefighter Safety - The safety of your firefighters is paramount. There isn't a house or property anywhere that is worth the injury or death of a firefighter! Is the route in and out safe? Is the fire behavior too extreme? Are there overhead power lines that you should concern yourself with? Are there LPG tanks, stored hazardous materials, or other

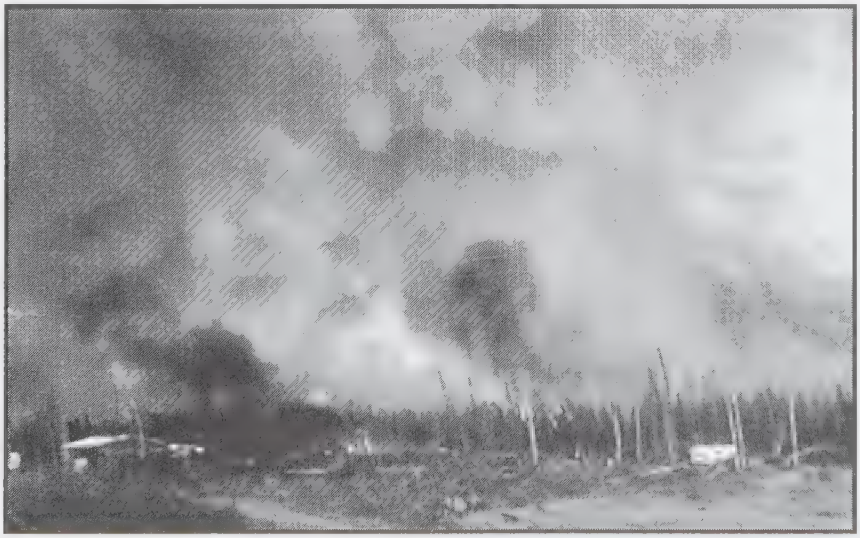


Figure 10.21 This fire is crowning and moving into a rural residential area. Unless there is a lot of clearance, it will be practically impossible to protect most threatened structures.

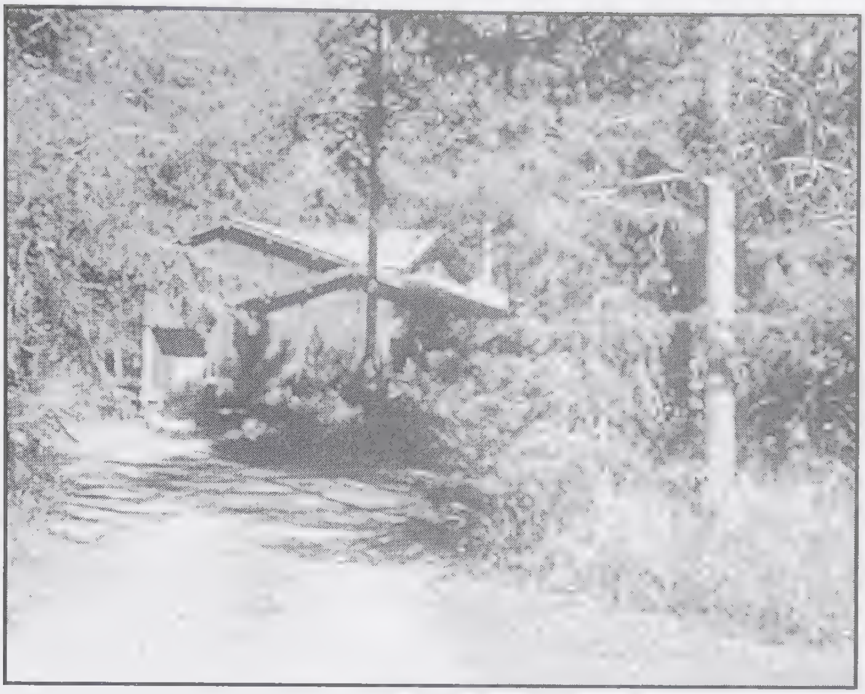


Figure 10.22 *Will it be safe to park your engine near this home and attempt to protect it under extreme fire behavior? Probably not!*

If the fire moves through the area, will you be safe?

special concerns (Figures 10.22 and 10.23)?

As we have discussed, there are many things to consider when developing your plan and deciding which structures to defend. The following structure triage situations identify some of the many factors you have to consider (Figure 10.24 - 10.28).

As a fire officer, one of the difficult decisions you will have to make is determining that a house cannot be saved, especially with the owner standing next to you. If there is time, take a second to show empathy.

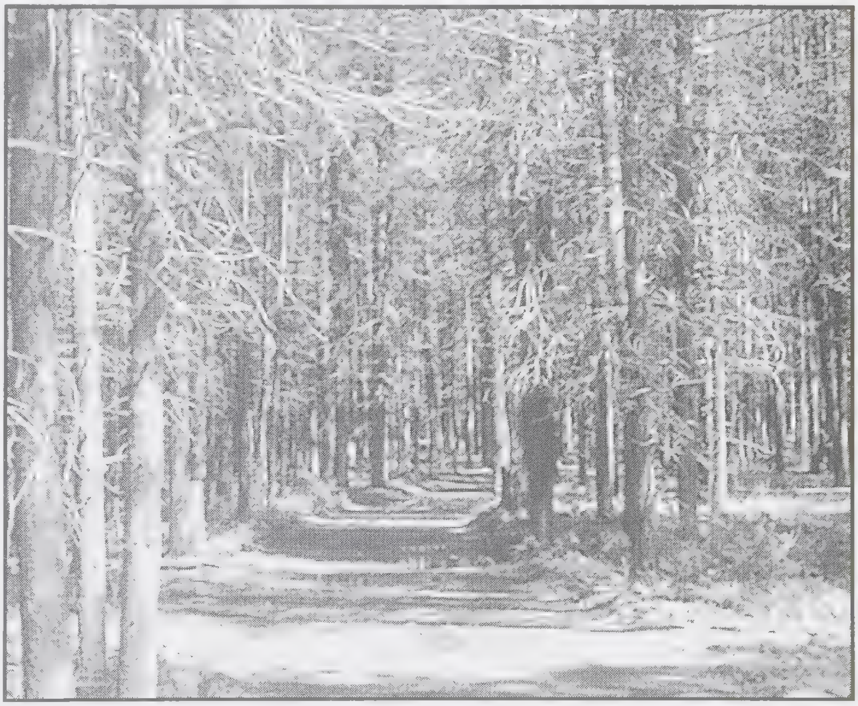
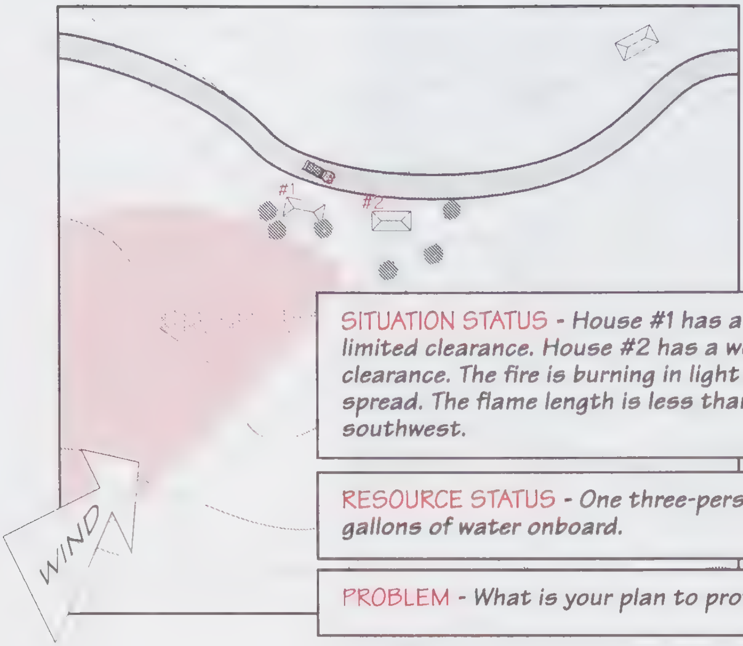


Figure 10.23 *This is not a road you want to travel if there is fire in the area. There is no clearance whatsoever. Imagine trying to move down this road at night, in the smoke, with fire on your tail! This is a dangerous situation.*



STRUCTURE TRIAGE SITUATION #1

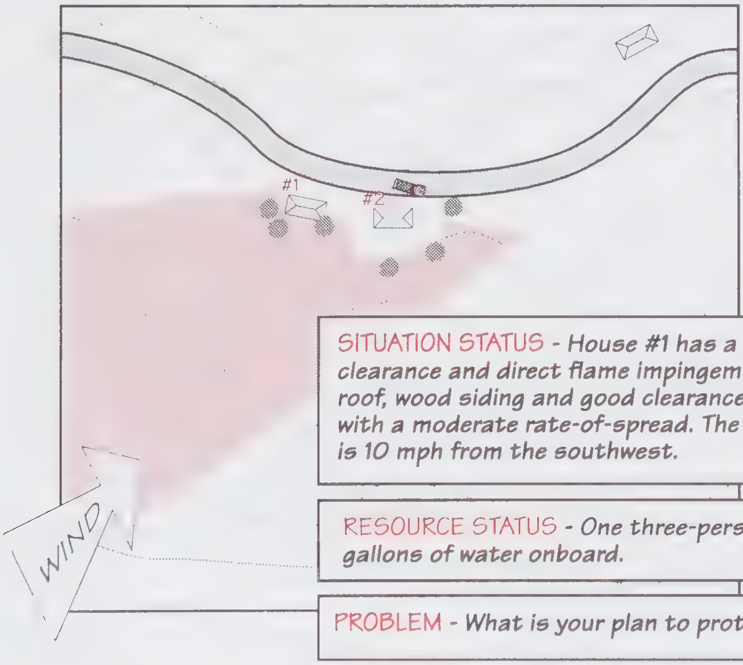
SITUATION STATUS - House #1 has a wood-shake roof, wood siding and limited clearance. House #2 has a wood-shake roof, wood siding and good clearance. The fire is burning in light duff and grass, with a slow rate-of-spread. The flame length is less than 2 feet. The wind is light from the southwest.

RESOURCE STATUS - One three-person engine is available. It has 500 gallons of water onboard.

PROBLEM - What is your plan to protect these houses?

SOLUTION - Since the fire is burning with relatively low intensity in light fuels, with limited firebrands, control the fire at House #1 letting the fire move past the second house. You can probably save both houses.

Figure 10.24 Structure Triage Situation #1 involves the protection of two houses in a rural area. The houses are similar, except one has better clearance than the other.



STRUCTURE TRIAGE SITUATION #2

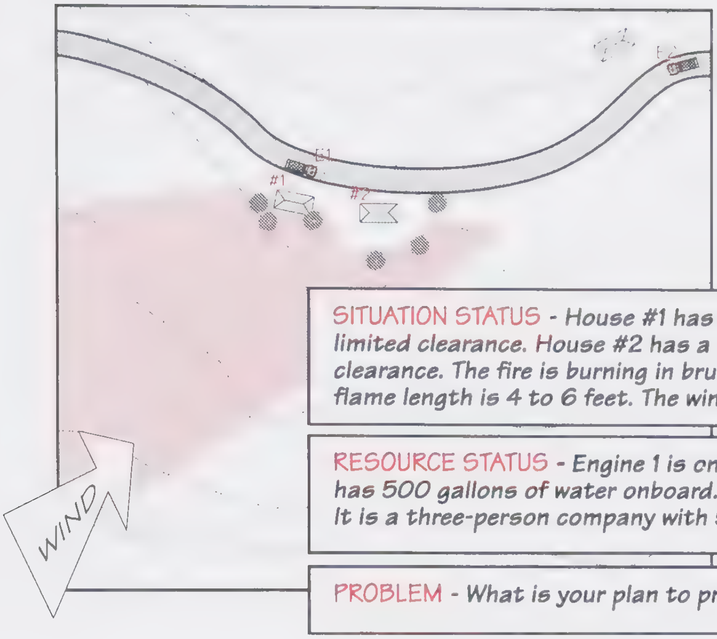
SITUATION STATUS - House #1 has a wood-shake roof, wood siding, limited clearance and direct flame impingement. House #2 has a wood-shake roof, wood siding and good clearance. The fire is burning in light brush, with a moderate rate-of-spread. The flame length is over 4 feet. The wind is 10 mph from the southwest.

RESOURCE STATUS - One three-person engine is available. It has 250 gallons of water onboard.

PROBLEM - What is your plan to protect these houses?

SOLUTION - With your limited water supply, level of fire behavior and limited clearance around House #1, it is lost. You probably have enough water to protect House #2 from firebrands. Saving House #2 should be your priority.

Figure 10.25 Structure Triage Situation #2 has the same two structures threatened, but the fire behavior is much more severe and there is limited water.



STRUCTURE TRIAGE SITUATION #3

SITUATION STATUS - *House #1 has a wood-shake roof, wood siding and limited clearance. House #2 has a wood-shake roof, wood siding and good clearance. The fire is burning in brush with a moderate rate-of-spread. The flame length is 4 to 6 feet. The wind is 8 mph from the southwest.*

RESOURCE STATUS - *Engine 1 is on scene; it is a three-person company. It has 500 gallons of water onboard. Engine 2 will be on scene in five minutes. It is a three-person company with 500 gallons of water.*

PROBLEM - *What is your plan to protect these houses?*

SOLUTION - *Since the fire is burning with moderate fire behavior in brushy fuels, protecting House #1 may be possible, if quick action is taken. Position Engine 1 to protect it. When Engine 2 arrives assign it to protect House #2, and to assist you, if necessary. It may be possible to save both houses.*

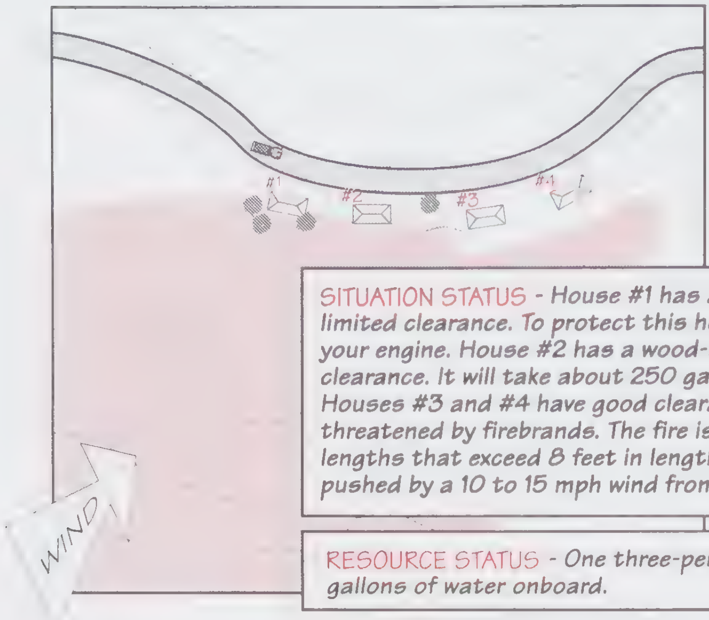
Figure 10.26 Structure Triage Situation #3 again involves the protection of two houses. This time a second engine is available in about five minutes.

Some owners will be understandably angry no matter how obvious the reason for your decision.

There is no simple rule regarding when you should abandon the effort to protect a structure. Rely on your judgment to guide you. Err on the side of safety. The following is a list of factors or conditions that may indicate that it is time to move on:

- The fire is making significant runs (not just isolated flare-ups) in the standing live fuels, and the structure is less than two flame lengths from those fuels.
- Spot fires are igniting around the structure or on the roof faster than you can put them out.
- Your water supply is insufficient to allow you to continue firefighting until such time as the threat subsides.
- You cannot safely remain at the structure and your escape route could become unusable.
- The roof is more than one fourth involved in windy conditions, and other structures are threatened or involved.
- Interior rooms are involved and windows are broken. It is windy, and other structures are threatened or involved.

Err on the side of safety.



STRUCTURE TRIAGE
SITUATION #4

SITUATION STATUS - *House #1 has a wood-shake roof, wood siding and limited clearance. To protect this house it will take all of the tank water of your engine. House #2 has a wood-shake roof, wood siding and good clearance. It will take about 250 gallons of water to protect this house. Houses #3 and #4 have good clearance; they will probably only be threatened by firebrands. The fire is burning in heavy brush, with flame lengths that exceed 8 feet in length. The rate-of-spread is moderate, pushed by a 10 to 15 mph wind from the southwest.*

RESOURCE STATUS - *One three-person engine is available. It has 500 gallons of water onboard.*

PROBLEM - *What is your plan to protect these houses?*

SOLUTION - *You have three options to consider: (1) If you position to save House #1, you may be able to save it, but use up all of your water in the process. The other three houses may be lost. (2) If you position to protect House #2 you will save it using about half of your water. You can then move to protect Houses #3 and #4. (3) If you position to protect Houses #3 and #4, you will save them, but Houses #1 and #2 will be lost. Option #2 is your best one. You have the potential of saving Houses #2, #3 and #4; three out of four is probably the best you can expect in this situation.*

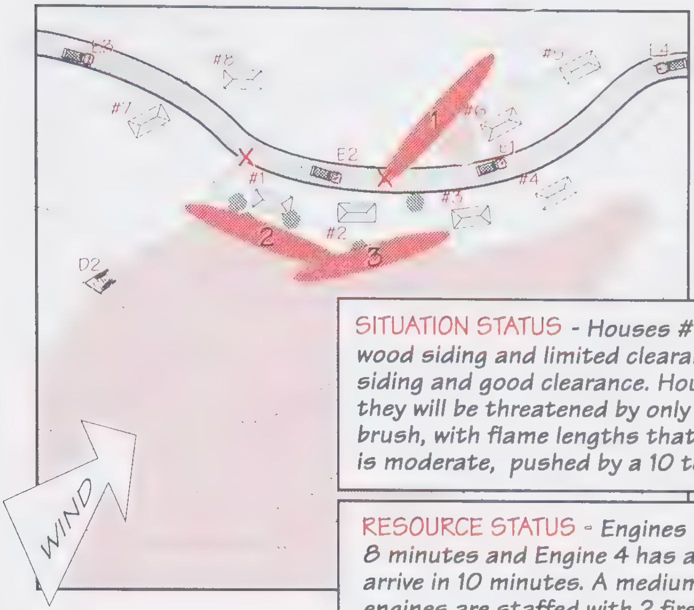
Figure 10.27 Structure Triage Situation #4 involves four houses that are threatened; you have two engine companies available.

Evacuation

When do you attempt to evacuate an area? As a fire officer, this may be one of your tougher calls. Sometimes you will not have to say anything to the residents. At the first sign of smoke, they will choose to leave. But there are people who will not leave under any circumstances. Fire personnel can suggest and recommend evacuations, but it is the responsibility of law enforcement personnel to move people against their will.

Deciding when to evacuate is a tough call.

There are two basic reasons to evacuate an area: to move the residents out of harms way, and to clear the area so that firefighting personnel can move about more freely. The first of these reasons is obviously the most important.



STRUCTURE TRIAGE SITUATION #5

SITUATION STATUS - *Houses #1, #5, #6 and #8 have wood-shake roofs, wood siding and limited clearance. House #2 has a wood-shake roof, wood siding and good clearance. Houses #3, #4 and #7 have good clearance; they will be threatened by only firebrands. The fire is burning in heavy brush, with flame lengths that exceed 8 feet in length. The rate-of-spread is moderate, pushed by a 10 to 15 mph wind from the southwest.*

RESOURCE STATUS - *Engines 1 and 2 are on scene. Engine 3 has an ETA of 8 minutes and Engine 4 has an ETA of 15 minutes. A heavy airtanker will arrive in 10 minutes. A medium bulldozer has an ETA of 10 minutes. All the engines are staffed with 2 firefighters. No other firefighting resources will be available for hours. The fire is burning in brush, with scattered patches of grass or lighter fuels. The flame lengths in the brush are from 6 to 8 feet. The flame lengths in the grass are about 4 feet. The fire has spotted across the road in light grass and is threatening House #6. The wind is from the southwest at about 8 mph.*

PROBLEM - *What is your plan to protect these houses?*

SOLUTION - *Your first priority is to control the spot fire north of the road. Engine 1 should position to protect House #6 and take action on the spot fire. Engine 2 should position to protect Houses #2 and #3. Engines 3 and 4 should be used to protect other houses as they become threatened. Dozer 2 can be assigned to begin constructing fireline from the road. If needed, it can be used to construct a firebreak between the houses and the fire. The airtanker should be instructed to assist Engine 1 in controlling the spot fire. It can then be told to start applying retardant to protect the structures, and then to assist Dozer 2 in constructing fireline.*

Figure 10.28 Structure Triage Situation #5 involves eight threatened structures. You have a full first alarm, including a bulldozer and heavy airtanker.

The decision to evacuate must be made as early in an event as possible, by an official with the authority to carry it out, and in concert with the local law enforcement agency. The following factors must be considered:

Can you evacuate an area safely?

- **Fire behavior** - What are the rate-of-spread, spotting conditions, and the overall intensity of the fire? Does the fire behavior pose a real threat to the residents? How reliable is the information about the fire?
- **Timing** - When will the fire be in the area? Is there enough time to develop an evacuation plan, notify the

appropriate authorities, communicate to the residents that they must/should leave, and then move them from the area? There may be times when it would be best to have them stay put rather than risk being caught by fire while trying to evacuate.

- **The threatened population** - How many people have to be moved? What are their ages? Are there any special problems or considerations? Will people be forced to leave if they don't want to go?
- **Roads** - Are the evacuation routes capable of handling the anticipated traffic loads? Are these the same routes responding fire apparatus will be using? Are the escape routes safe to use with fire in the area?
- **Security** - How will the area be protected from the possibility of looters? What security measures will have to be put in place? Who will do this?

Is there time to evacuate the area?

In most cases, when an evacuation is implemented, it is decided to do so quickly and without a formal plan. But, if time allows, develop a formal plan that addresses the timing of the evacuation (when people will be asked to move), the routes they will take (hopefully not the same routes fire apparatus are using), and the locations to where people will be moved. You will also have to involve the Red Cross or other appropriate agency to arrange for the housing and feeding of evacuees.

Don't call for an evacuation if you don't have a plan.

If, on the other hand, you decide not to evacuate, how do you turn the people who stay into an asset? Residents can provide information on the location of all the structures in the area, sources of water, the road system, and any special hazards.

They can also help prepare structures for defense by moving flammable materials away from the structure, clearing the roof and gutters of litter, closing windows and curtains, and so on. They can sometimes assist fire department personnel with the actual defense of a structure. However, be very careful that residents are not put in any situation that may get them injured.

Preparing the Structure

If time allows, there are several things you can do to make your job of protecting the structure easier (Figure 10.29). Conditions to be considered are:

Defensible space - Remove flammable material from the area. If the yard is cluttered with flammable material (firewood, scrap lumber, trash, etc.), move it well away from the structure. If there is grass or brush close to the structure, cut it back. Limb up trees, reducing the ladder fuels. Do whatever is reasonably necessary to give yourself some working room and to reduce the potential for convective and radiated heat to ignite the structure. The amount of defensible space needed depends on the anticipated fire behavior. Clearance should be at least two times the flame length—three times, if possible. If the fire will be approaching from below, the steepness of the slope will dictate even greater clearance.

If you have time, improve the defensible space.

The structure's exterior - Plug holes and unscreened vents. Clear the roof and rain gutters of litter. Cover evaporative coolers; turn off the blower. Turn off the gas at the meter or at the LPG tank. Leave the electricity on unless there is fire inside the structure and you will be attacking it.

The structure's interior - Close the doors and windows; close the drapes if they are of a heavy material or will not easily ignite. Turn off fans, coolers, air conditioners, etc. Turn on the porch light. Make sure external doors are unlocked, but closed.

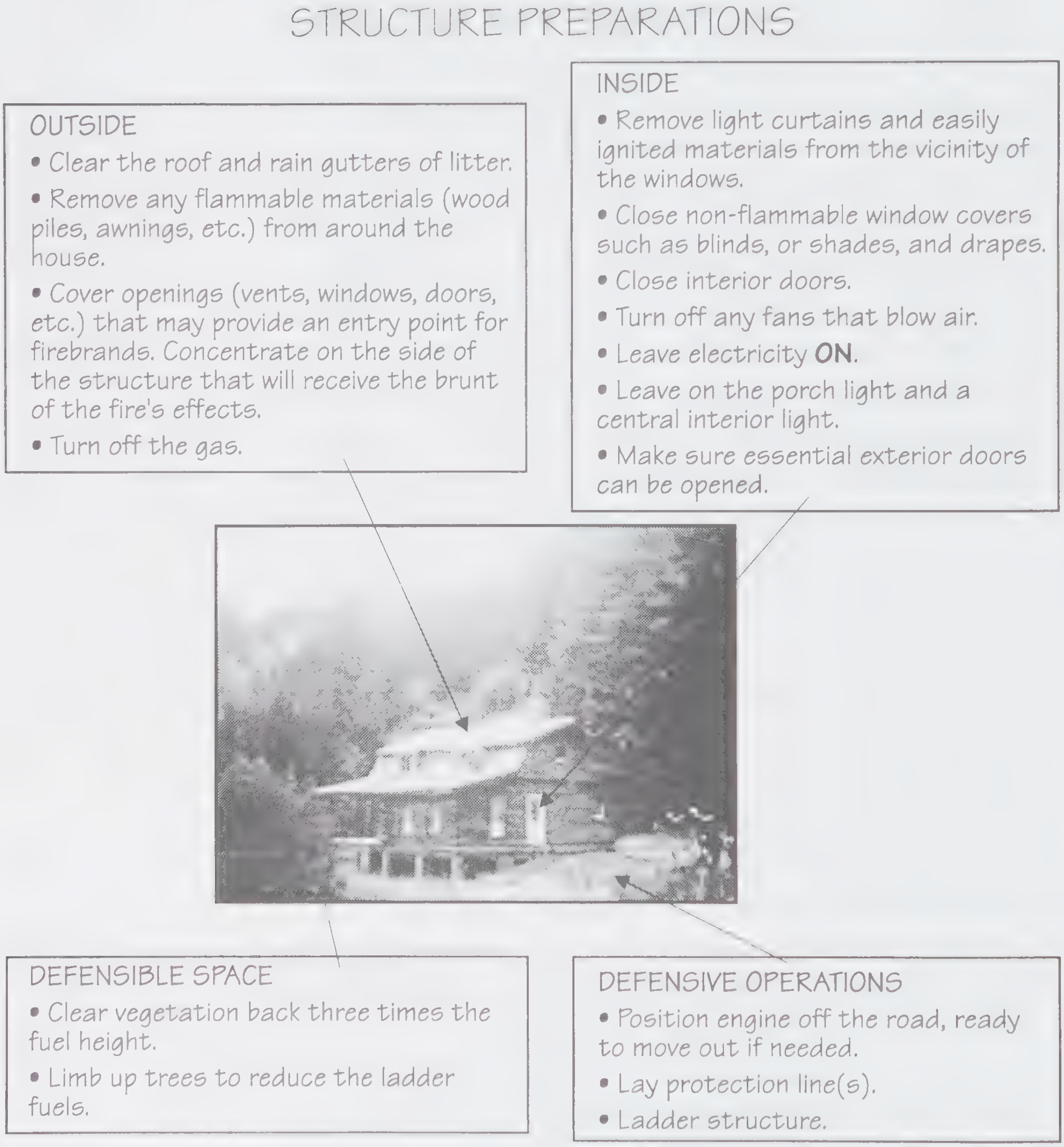
Hazards - Some of the more common hazards are LPG tanks, aboveground fuel storage tanks, junk cars, and miscellaneous car parts (shocks, fuel or air tanks, mounted tires, drivelines, etc.). Clear flammable fuels from around these items.

Are there special hazards associated with the area you will be protecting?

Pets and livestock - If you will have to deal with a lot of animals, have animal control personnel called out. You may have to free penned or chained animals; most of the time they can avoid being hurt if they can move freely. Household pets may have to be confined to the house or garage.

Fireline construction - There may be times that you need to construct fireline just to protect a structure or group of structures. The placement of this fireline is critical. The fireline should be placed well away from the structures so that radiated and convected heat cannot ignite them. The slope, wind, and type of fuel will dictate the necessary fireline width. You may allow the fire to move to this line; however, most often you will fire it out, widening the buffer between the fireline (and structures) and the main fire.

On-site protection - Ladder the building, using the owner's ladder when possible, keeping the ladder on the engine so that if you have to leave quickly, it isn't something else you have to collect. Place the ladder on the side of the structure away from the heat of the fire, in a visible location, and close to where your hose



STRUCTURE PREPARATIONS

OUTSIDE
- Clear the roof and rain gutters of litter.
- Remove any flammable materials (wood piles, awnings, etc.) from around the house.
- Cover openings (vents, windows, doors, etc.) that may provide an entry point for firebrands. Concentrate on the side of the structure that will receive the brunt of the fire's effects.
- Turn off the gas.

INSIDE
- Remove light curtains and easily ignited materials from the vicinity of the windows.
- Close non-flammable window covers such as blinds, or shades, and drapes.
- Close interior doors.
- Turn off any fans that blow air.
- Leave electricity **ON**.
- Leave on the porch light and a central interior light.
- Make sure essential exterior doors can be opened.

DEFENSIBLE SPACE
- Clear vegetation back three times the fuel height.
- Limb up trees to reduce the ladder fuels.

DEFENSIVE OPERATIONS
- Position engine off the road, ready to move out if needed.
- Lay protection line(s).
- Ladder structure.

Figure 10.29 If time allows, there are many things you can do to make the task of defending a structure easier.

lines will be positioned. Move private vehicles out of your way and to a sheltered location away from the heat and firebrands. Park them headed out, unlocked, with the keys in the ignition and the windows up. Be sure they are not parked on flammable fuels.

Defending the Structure

When moving into an area, plan for your escape.

The job of protecting structures from an advancing wildland fire is usually assigned to engine companies. In this process, the engine crew stays with the structure until the fire passes (unless it is prudent to leave sooner). Once the structure is safe, the engine company may be moved to protect another threatened structure.

Moving into an area - As you move into an area to protect structures, take note of such things as the terrain, fuels, and landmarks. The next time you see this area it may be thick with smoke, and on fire. Look for potential safety zones, other ways to leave the area, water sources, etc. (Figure 10.30).

Engine placement - When you arrive at the structure(s) you will be protecting, back in from the last known turnaround so that you don't have to back up if you have to leave quickly. Move near the structure, but not next to it, so that you reduce the length of your hose lays. If possible, park on the side away from the advancing fire. In this way, the structure will provide some protection. Do not park near flammable vegetation, under power lines, or near LPG tanks. Park off the roadway to make room for others to pass. If you have to park in grass, scrape or burn an area to park in. Close the doors and windows on the engine. Be sure that any flammable material,

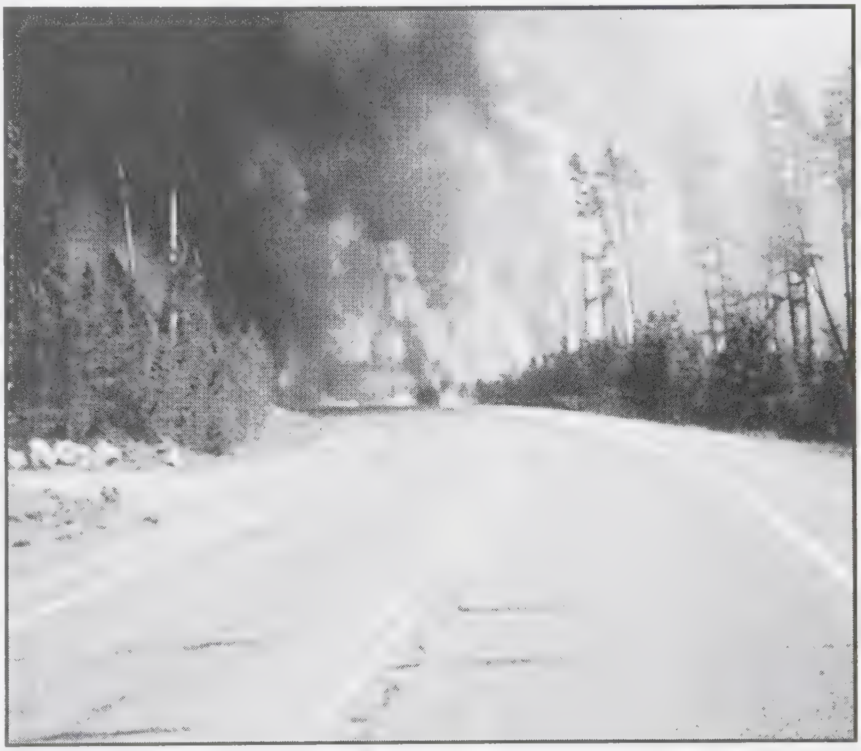


Figure 10.30 This road is narrow and already has fire near it. Is this a place you want to be?

such as "out of county bags" and tents, are stowed in a cabinet or in the cab. As much as possible, reduce the possibility that you have to switch from protecting the structure to protecting your engine (Figure 10.31).

Be sure to prepare your engine.

ENGINE POSITIONING AND SETUP

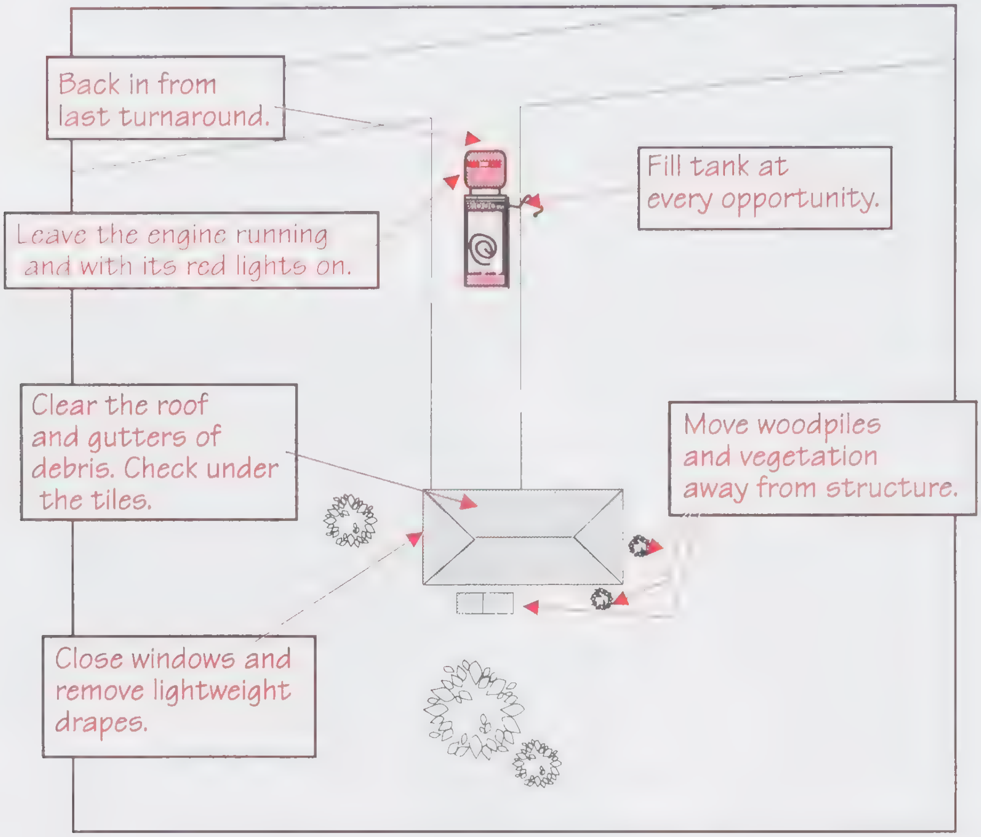

Back in from last turnaround.
Fill tank at every opportunity.
Leave the engine running and with its red lights on.
Clear the roof and gutters of debris. Check under the tiles.
Move woodpiles and vegetation away from structure.
Close windows and remove lightweight drapes.

Figure 10.31 Position your engine so it will not have to be protected.

Pre-plan your defense - Walk around the structure and anticipate where and when the fire will strike. Decide when and how you will start your defense. Discuss with your crew what they are to do. Also, discuss what they are to do if things start to go bad. Have a plan and ensure that everyone knows it.

Plan your defense.

Defensive strategies - There are three main defensive strategies in structural protection: full containment, partial containment, and no containment. Through triage, you decide what is possible. The three primary strategies for **full containment** are:

- Stopping the fire before it reaches the structure.
- Suppressing the fire's edge as it nears.
- Firing out from control lines.

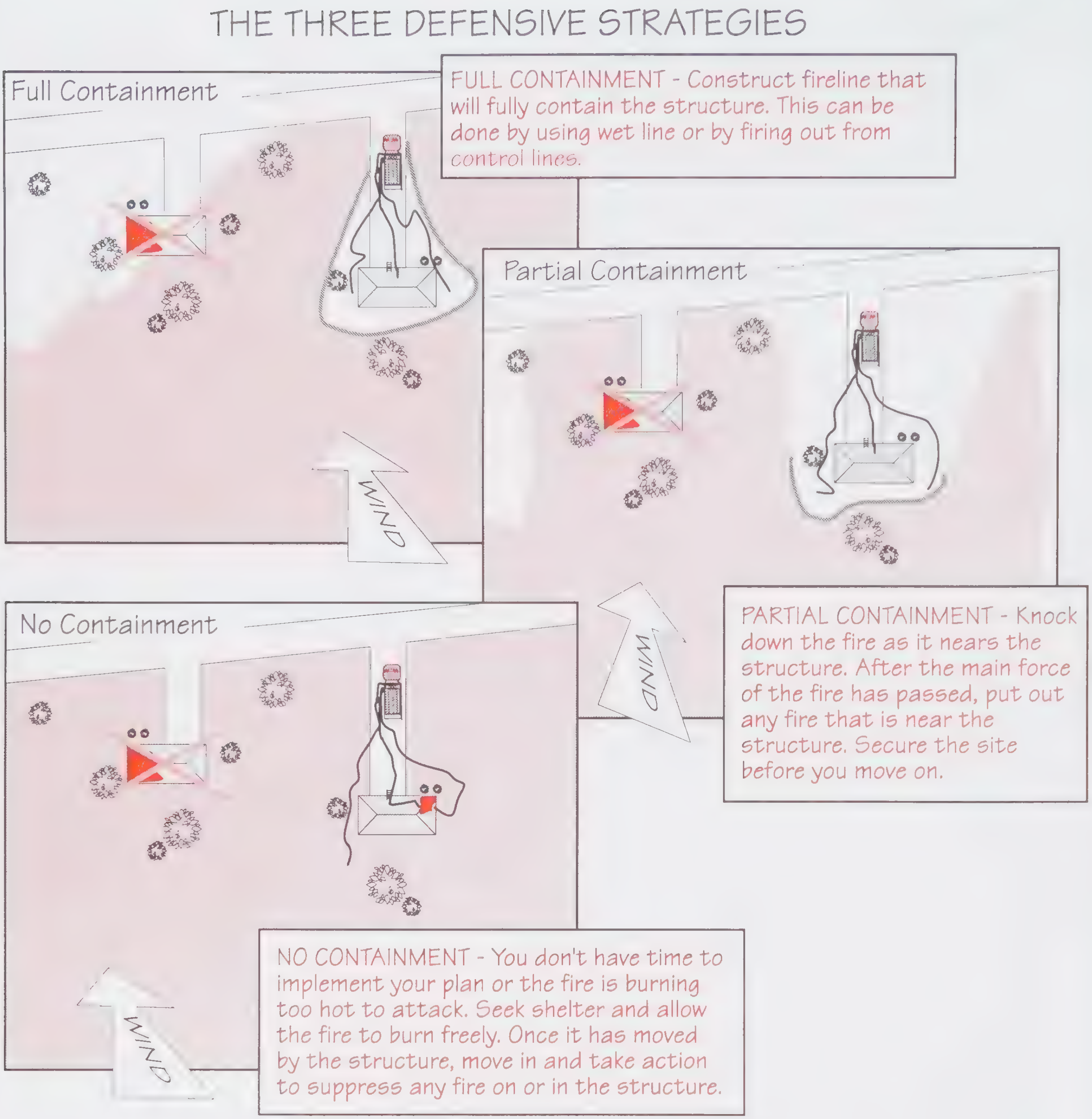
If full containment is not possible, you may be able to defend the structure using a **partial containment** strategy. In this case, you knock down the fire as it approaches, allowing the fire to pass by on the sides. After the fire passes, you put out the remaining fire near the structure. In a **no containment** strategy, you don't have time to implement any other plan, or the fire is burning too hot to attack. In this strategy, you allow the fire to pass, while you protect your crew and engine. After it has passed, you move in to suppress any fire that has started in or on the structure (Figure 10.32).

There are three containment strategies.

Positioning hose lines - You need to lay enough line to protect the structure; however, remember that you will have to pick up all of the hose you lay. The best working lines are either 1½-inch or 1¾-inch lines. They can provide the volume of water you need, but they can still be easily moved and handled. Hard lines or booster lines may be convenient, but they may not be able to provide the water volume you need, and you cannot easily disconnect or abandon them if you have to "cut and run." Use a combination nozzle if you can. Lay two lines, one around each side of the structure. This ensures that you have the structure covered. It also gives you a backup if one line fails. Connect all of your lines to the pump-panel side of the engine. This will save you time if you have to leave quickly. Know what line will be moved to the roof if that becomes necessary. It may be one of the two lines already laid, or it may be necessary to deploy an additional line. Also, make sure you have a line ready to protect the engine if it becomes threatened. Make sure all of the lines are charged and ready for use (Figure 10.33).

Lay out only those lines you can staff. The more hose you lay out, the more you have to pick up.

Protecting the roof - Usually the first assault the fire makes on a structure is from the air. Firebrands may rain down on the structure and surrounding area. If a roof fire starts, deal with it immediately. If the fire is small, extinguish it and ensure that all burned material is removed. If the fire is spreading across the



THE THREE DEFENSIVE STRATEGIES

FULL CONTAINMENT - Construct fireline that will fully contain the structure. This can be done by using wet line or by firing out from control lines.

PARTIAL CONTAINMENT - Knock down the fire as it nears the structure. After the main force of the fire has passed, put out any fire that is near the structure. Secure the site before you move on.

NO CONTAINMENT - You don't have time to implement your plan or the fire is burning too hot to attack. Seek shelter and allow the fire to burn freely. Once it has moved by the structure, move in and take action to suppress any fire on or in the structure.

Figure 10.32 There are three defensive strategies that you can use to protect a structure.

roof, the structure is in serious trouble. Attack from the exterior and attempt to stop the spread. Also, move into the structure and attack the fire from below. Don't hesitate to pull ceilings to gain access to the roof structure. If more than one fourth of the roof is involved and you aren't making any headway, the structure may be lost. Move on to one you may be able to save.

HOSE LINE POSITIONING AND SETUP

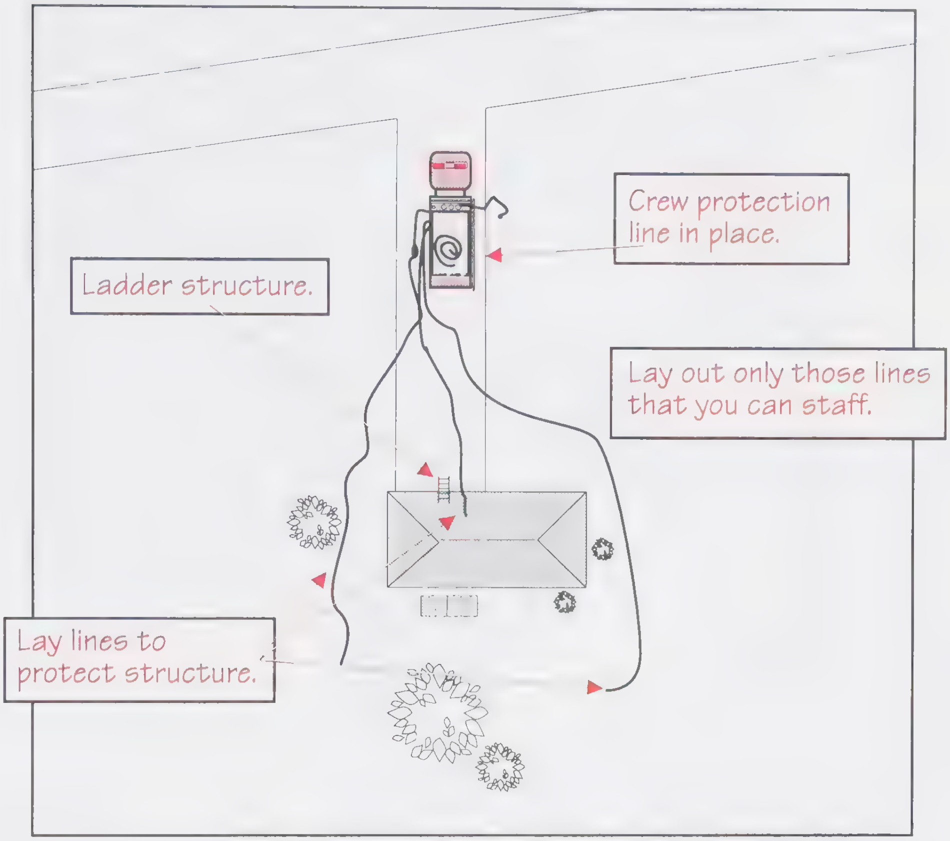

Crew protection line in place.
Ladder structure.
Lay out only those lines that you can staff.
Lay lines to protect structure.

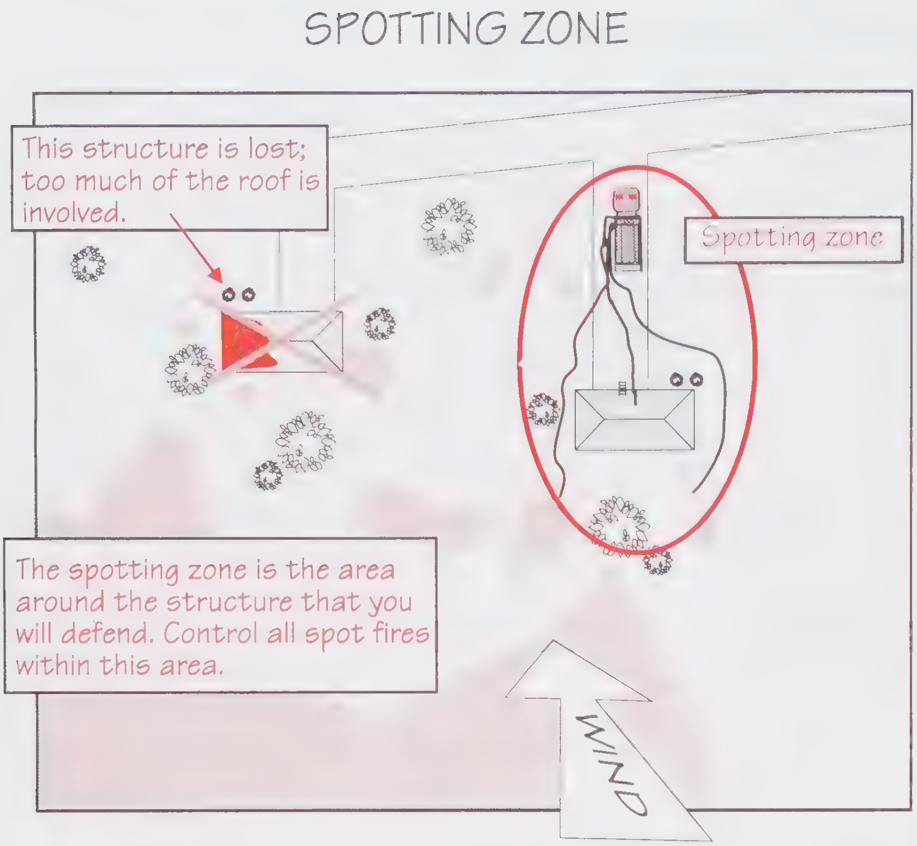
Figure 10.33 Hose line placement is critical. Be sure that the lines are well placed and charged.

Interior attack - All interior attacks must be made by firefighters who are in full turnouts and breathing apparatus. Work to suppress any fire on the interior of the structure. If it is well seated and you don't have a good water supply, the structure, again, may be lost. If you suspect fire has moved through vents into an attic, check it out. Many a structure has been lost because a small fire in the attic space was overlooked.

Don't attempt an interior attack without being properly dressed.

Creating a spotting zone - Create a spotting zone around the structure within which you will attack spot fires. Spot fires usually start well before the main fire front arrives. In fact, the main fire may not arrive for hours. Be sure that your hose lines cover all of the area you consider the spotting zone. Move around looking for and suppressing the spots as they occur (Figure 10.34).

Establish a spotting zone.



SPOTTING ZONE

This structure is lost; too much of the roof is involved.

The spotting zone is the area around the structure that you will defend. Control all spot fires within this area.

Figure 10.34 Designate a spotting zone: an area where you will attempt to suppress all spot fires.

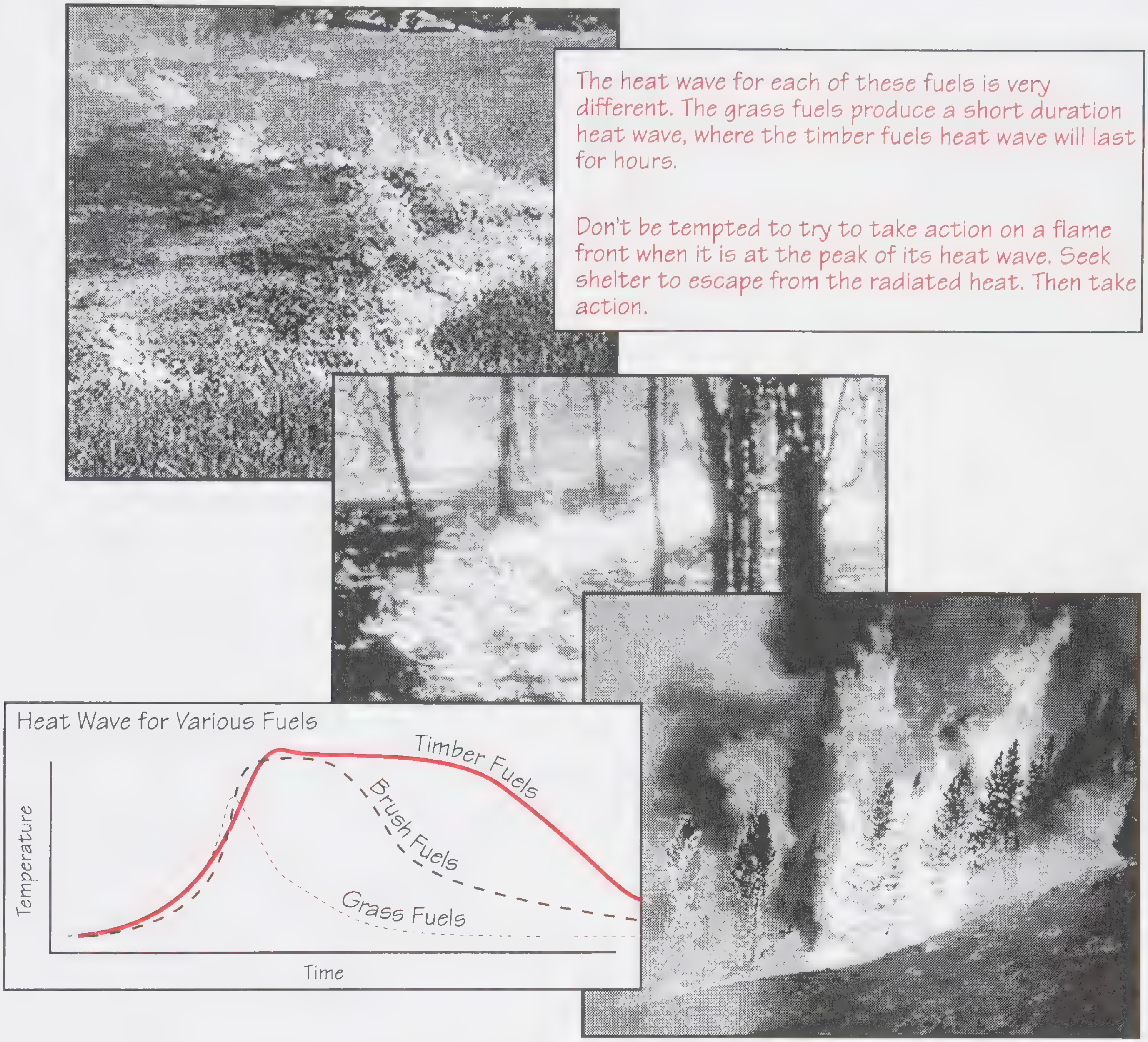
Reducing the heat - As the main fire approaches, reduce the heat from hotspots if you can. Use the hose lines to knock down flare-ups as they occur. Don't just stand there wasting water by launching it into the air. **Wetting down an area is a waste of time and water**. Use the limited water you have to actually suppress the fire. Use the water to reduce or limit the buildup of heat. Use it to prevent the fire from getting into heavy fuels (patches of brush, wood piles, lumber), and use it to knock down surface fires so that the fire doesn't move into the aerial fuels.

The heat wave - As the fire moves near your location, heat will build up. The duration of this buildup is controlled by the fuels that are burning, as well as the overall fire behavior. In light fuels, the flame front may pass by very quickly, often in minutes. In brush, the burn out time may take 10 to 15 minutes. If you are protecting a structure located in or near heavy fuels, the duration of the heat may be hours. Many a structure has been lost because of the accumulated effect of radiated heat over a long period of time. As the heat peaks, you may have to seek refuge behind the structure or even inside. Don't launch water into the flame front. As previously noted, you will be wasting water. Move back until the fire has passed and then take whatever action you can.

Don't launch water into a flame front. It is a waste of water.

When the fire is controllable, limit the heat build-up by keeping fire out of heavier fuels. Work on the fire where it has moved into lighter fuels. At the other extreme, wait until the worst of the heat wave has passed, then put water on the structure or on

THE HEAT WAVE



The heat wave for each of these fuels is very different. The grass fuels produce a short duration heat wave, where the timber fuels heat wave will last for hours.

Don't be tempted to try to take action on a flame front when it is at the peak of its heat wave. Seek shelter to escape from the radiated heat. Then take action.

Figure 10.35 As a fire moves closer to the structure, the temperature will increase. This is called the "heat wave." The duration of the heat wave is tied to the type of fuels and the level of fire behavior.

threatened fuels. In between these extremes, apply water only if it significantly reduces direct heat impinging on the structure (Figure 10.35).

Firing out - It is not uncommon for firefighters to be reluctant to fire out around a structure. However, this may be the only way to safely protect a structure. If an area is going to burn, why not burn it on your terms? If your plan is to burn out around a structure, don't wait too long. Do it early enough so that your fire can widen your control lines in time to do some good. Coordinate your burning operation with others. You don't want to start burning in an area that is planned to stay unburned. Also, you don't want to start a fire which will cause problems for other firefighters.

Coordinate your burning operation with those around you.

Aircraft - Airtanker and helicopter drops can be effective in protecting a structure from a wildland fire. Place the drops on the side of the structure that will be getting the majority of the heat. You can use drops to suppress fire that is near the structure, or to pre-treat fuels in order to slow the fire as it approaches.

Water supply - Water is always going to be in short supply. Use it wisely. Hold back about 100-gallons for use in case you need to protect your engine. Take advantage of any opportunity to add water to your tank. If there is a domestic water system available, try to find out its capacity, rate-of-flow, pressure, and reliability. Don't plan on protecting a structure based on the availability of a fire hydrant. It probably will be dry when you really need it. Swimming pools can be useful sources of water.

Hold back water in your engine to protect it and your crew.

Use of foam - Class A foam is very useful in defending a structure from a wildland fire. Its ability to cling to vertical surfaces and its durability (staying power) are very useful. When applying foam to a structure, timing is critical. Foam applied too early may not have the durability to provide the best level of protection. Beginning to foam too late may not allow enough time to coat the entire structure. Begin treating about 10 to 15 minutes before the expected front arrives. Loft the foam from some distance, allowing it to build up in layers. Foam other hazards, like LPG tanks and aboveground fuel tanks.

Use foam if you can.

Staying Mobile - You have to remain mobile, not tied down to one spot for any length of time. There usually aren't going to be enough engines to protect all of the structures being threatened. As soon as one structure is saved, move to the next one. Try not to get tied to fire hydrants or large diameter hose lines.

"Is it time to cut and run?" - There may be times when the situation is deteriorating and you have to "cut your hose lines" and retreat to safety. If you have to move out, be sure to watch for hazards like downed powerlines, burning trees and snags, debris on the road (e.g., logs and rocks), smoky conditions, weakened bridges, or cattle guards. Move to a safety zone and wait out the fire, notifying your supervisor of your move. Then move back into the area to see what can be salvaged.

Keep your options open to move out of any area if safety becomes a concern.

Entering private property - If you are protecting a structure, you usually have access to the building. This means you may need to enter it to check for fire. Be sure that you and your people treat the residents' property as you would want yours to be treated. If you do enter a structure, leave a note as to who you were and what you did.

Use of Firefighting Resources

It is your responsibility, as a fire officer, to know the capabilities of the various tools that will be available to fight a fire. If you do not know the capabilities *and limitations* of engines, bulldozers, fire crews, firefighting aircraft, etc., you will not be able to use them safely, productively, and efficiently.

Engines

The engine company is the most versatile firefighting tool you have in your arsenal. It is self-contained: it has firefighters, equipment, water, hose, pump, communications equipment, and even some logistical support capabilities (e.g., it has its own means of transportation, rations, etc.). Engine companies can attack a fire with their hose lines, construct fireline with their hand tools, provide medical assistance, and perform many other tasks. When utilizing engine companies in firefighting, be sure that you match the type of equipment and personnel to the job.

Be aware of the engine company's capabilities.

Be aware that there are limitations to the use of structural engines off the road. However, a structural engine can be used on a mobile attack if the engine has pump-and-roll capabilities, the terrain isn't too rough, the soil is hard, and the fuels are relatively light. The engineer must be experienced and cautious. The same holds for engines if they have to use dirt roads. Proper caution and common sense should be observed in these situations.

A mobile attack can be very effective.

Mobile Attack - If the terrain, fuels, and fire behavior allow, and you have engines that can safely operate off the road, a mobile attack can be very effective (Figure 10.36). It is best if you can work engines in tandem. The lead engine company can move much faster if the crew knows an engine is following them and is in a position to pick up hotspots and slop overs. The two engine companies can also alternate as the lead engine so that one crew isn't exposed to the heat constantly.

A mobile attack is usually made directly on the fire's edge. The engineer and the firefighter on the nozzle must always be in visual contact. This constant visual contact prevents the firefighter from being injured by the engine and allows the firefighter to quickly warn the engineer of rocks, obstacles, and other hazards.

The engineer must know where everyone is at all times.

Figure 10.36 The engine company is a very versatile firefighting tool. It can be used quite effectively in a mobile attack.

Don't move too fast. If the fire breaks out behind you, you've lost your anchor point.

There may be times when the fire behavior will not allow you to safely conduct a direct attack. In these cases, the engine can be used to lay down a wet line from which a firing operation can be conducted. There may be other situations where an engine company can be used to follow up on airtanker or helicopter drops or a bulldozer, firing and holding the line they have constructed.

There are two very important safety points to remember when involved in a mobile attack: constantly be on the lookout for flare-ups behind you and always know where your firefighters are located. Before you start the attack, discuss what you will do if you have a flare-up and must move out of the area quickly. Have a plan, and be certain that everyone knows and understands the plan.

Protecting Structures - The engine company is the best tool you have for the protection of structures from an advancing wildland fire. This role of the engine company is so critical, it has been covered in considerable detail earlier in this chapter.

Not all engines are created equal.

When an Engine isn't an Engine - It is not uncommon that when you request engine companies for your fire, you don't get what you think you requested. You quickly come to find that **not all engines are created equal!** There are big ones, small ones, red ones, white ones, and those which can't leave the pavement. It is also true that **engines are only as good as those who operate them**. The personnel who staff the engines are also different in numbers, experience, training, and motivation. It is your job as a fire officer to maximize the productivity of the people and equipment you are provided with.

How you use an engine company will be influenced by the factors listed above. You should also be guided by safety concerns and good old common sense. You are not going to be very successful if you plan on having a Type 1 engine company from a large municipal department construct hand line or be responsible for the patrolling and mopping-up of a mile of dozer line. Likewise, you should not ask a two-person crew on a Type 6 engine to make an interior attack on a multistory commercial structure fire.

Match the engine company to the task at hand.

On simple fires in your home jurisdiction, matching the tool to the task is relatively simple. Usually, the proper equipment is dispatched, and the training and experience of the firefighters match the task at hand. The situation becomes much more complex when you are required to take an engine company out of its normal element and ask it to take on a task that is out of the ordinary. This problem presents itself most often when Type 1 engine companies or construction bulldozers are to used in a wildland fire attack (Figure 10.37).

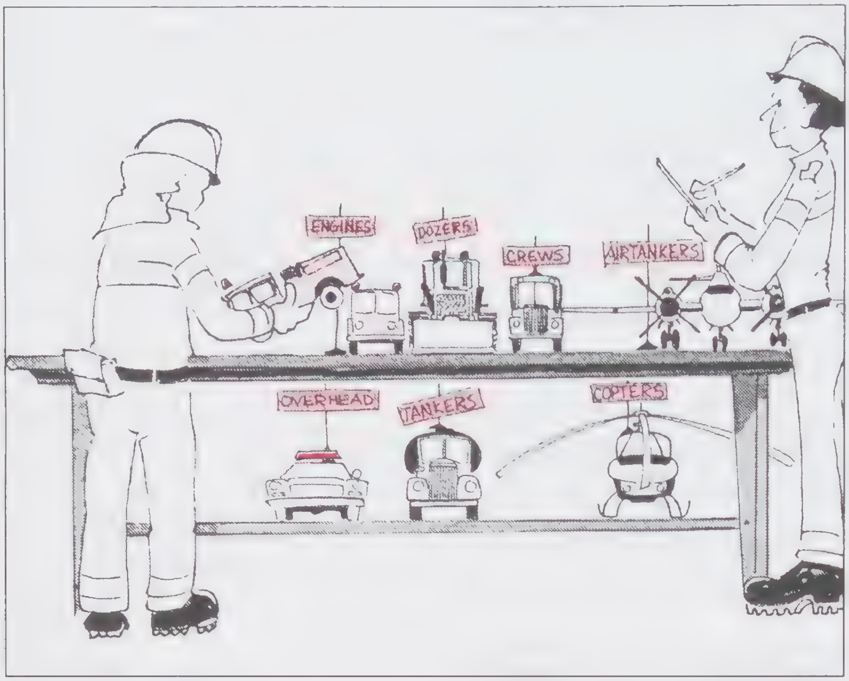


Figure 10.37 This fire officer is trying to match the firefighting resources he has to the right job.

The best way to maximize the use of Type 1 engines is to pair them with personnel who are familiar with wildland firefighting. Establish task forces that combine Type 1 or 2 municipal fire department engines with engine companies from wildland fire agencies. This system maximizes the efficiency of the companies and enhances safety.

Water Supply

Water may be available to you from many sources (e.g., fire hydrants, lakes, streams, ponds, or tanks). It can be brought to you in a water tender or by helicopter. Your responsibility is to know how to secure the water you will need and then to apply it at the right time in the right amounts. Be sure to ask your supervisor where your closest water source is. If you find a source, be sure to share this information with the other resources on the fire.

- **Fire hydrants** - Hydrants come in various sizes, shapes and capabilities. Most of the time, you will not find one in the wildlands, but sometimes you get lucky (Figure 10.38). Be prepared by having an assortment of adapters so that you can deal with different sized hydrant outlets and threads.
- **Lakes, streams, and ponds** - In most cases, if you find water in the woods, it will be in a lake, stream, or pond. Take only the water you need, and don't pollute the source. This may be the drinking water supply for the local community. To get the water from these sources, you may be able to do a direct draft with your engine's pump, use a gravity sock (Figure 10.39), ejector (Figure 10.40), or portable pump.
- **Tanks** - You may get lucky and find a tank or watering trough that will provide water. Or, you may move a tank into the area specifically for your use. Water can be supplied to these tanks from various sources, such as water tenders, helicopters, or a nearby stream.

Top off your tank at every opportunity.

Don't tie to fire hydrants. It may lead to wasting water.

Figure 10.38 A firefighter finds a fire hydrant under a bush.

Most of the time, you will have to hunt for water.

- **Water Tenders** - Like engines, water tenders come in varying sizes, shapes, and capacities. Try to match what you need with what you have assigned. Since most water tenders come from the private sector, they can be very expensive. Be sure to use them as effectively as you can. You may

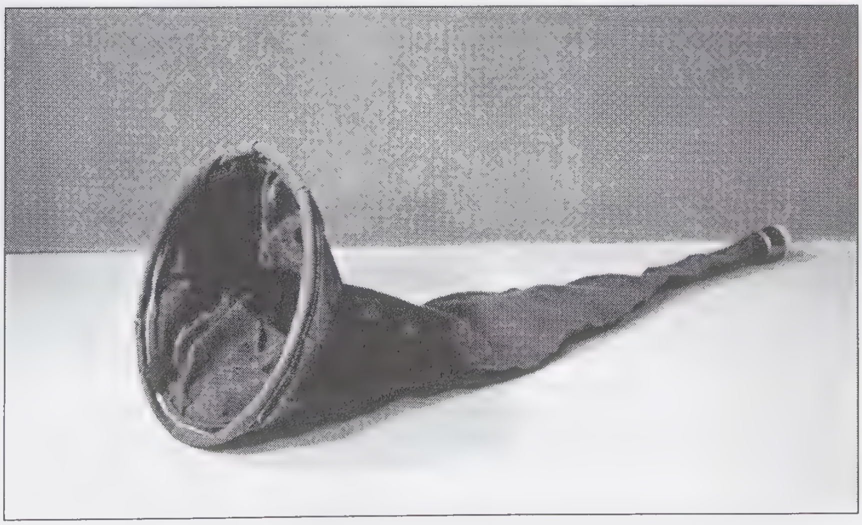


Figure 10.39 Gravity socks are used to funnel water into a hoselay, where gravity is used to "supply" the pressure.

A gravity sock is a unique way to capture water from a mountain stream.

have to spend some time calculating the water requirements so that you can determine how many water tenders you need.

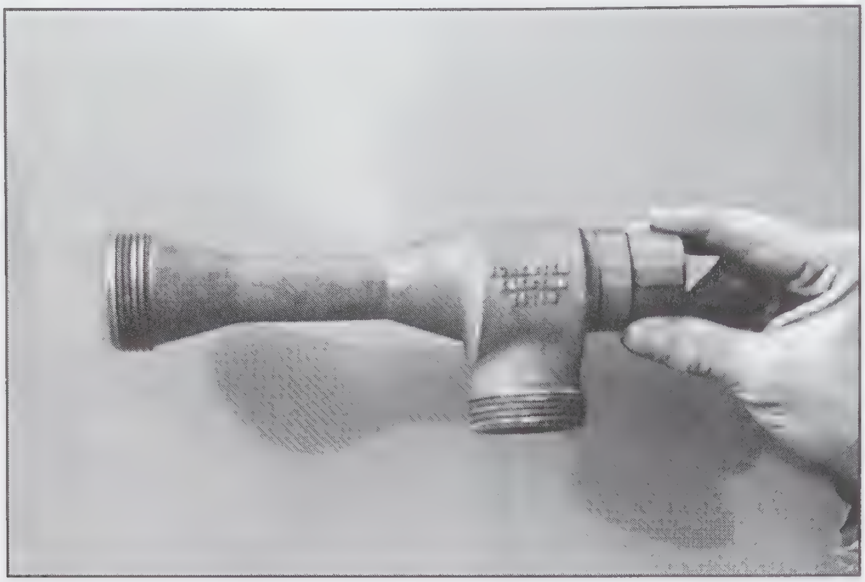


Figure 10.40 An ejector is used to draw water from a water source. You will need enough water in your engine's tank to fill the hose lines from the engine to the ejector.

Class A Foam

It would take an entire book to thoroughly cover the use of Class A foams on wildland fires. The fire officer needs to know if Class A foam is available, and how to use it if it is. Once you become familiar with it, you will never want to be without it in a real firefight. These highly concentrated foams can be applied through an aspirated nozzle (Figure 10.41) or through a compressed air foam system (CAFS) (Figure 10.42).

Class A foam can be very effective.

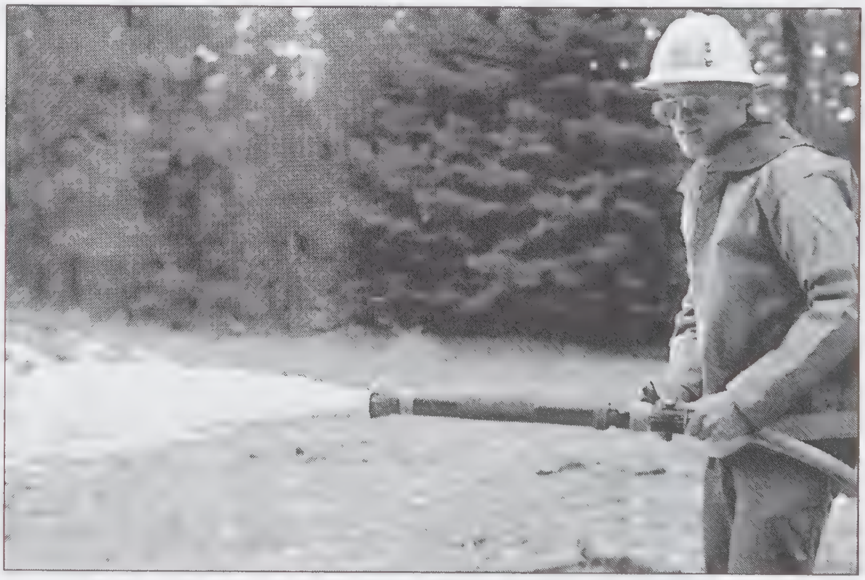


Figure 10.41 Class A foam can be effectively applied using an aspirated nozzle.

Bulldozers

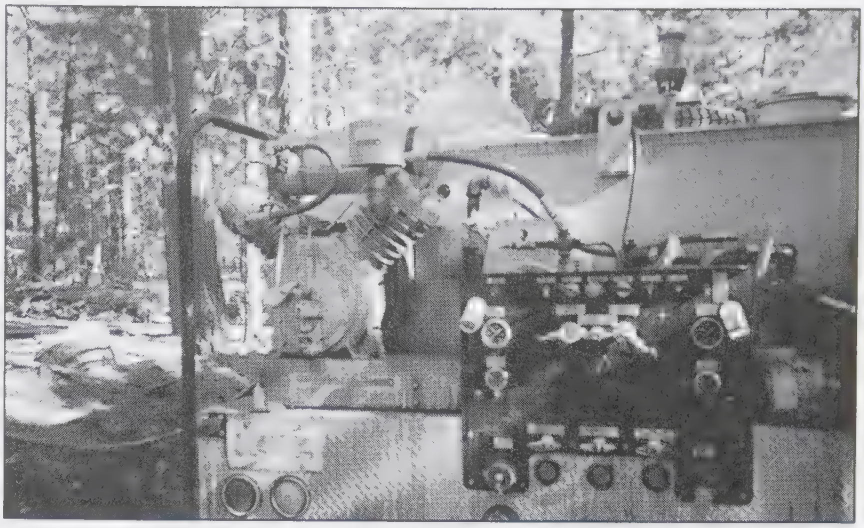


Figure 10.42 Compressed air foam systems are becoming very popular, but they are expensive. They use an air compressor to inject air into the hose stream, agitating the water/foam concentrate into a very foamy lather.

Bulldozers can perform several functions on a wildland fire. They can be used to construct fireline, to aid in mop-up, or to create safety zones and escape routes. They can be used in logistical support in the development of access routes and helispots. They can also be used during the rehabilitation phase of the fire to construct waterbars, to scatter piles, or to pull fireline berms.

Some of the general rules to keep in mind when using bulldozers are as follows:

- Have the operator remove only the fuels needed to construct the fireline. Don't build freeways when you don't have to.
- Be sure that bulldozers are well supervised. Most environmental damage occurs when bulldozers are allowed to freelance.
- When possible, mix hired bulldozers with agency bulldozers.
- Always support bulldozer operations with an engine, handcrew, or air operations, etc.
- Ensure there is a properly trained "swamper."
- Make sure the bulldozer has proper communication capabilities.
- Fire out the line as needed. Bulldozer constructed fireline is often lost if it is not fired out.
- Match the bulldozer size to the task at hand. Big machines for large fuels; smaller machines for grass and light fuels. Keep in mind that you don't always need the biggest bulldozer you can get; smaller bulldozers can be very productive.

Don't build a freeway if you don't have to.

When developing plans to construct fireline using bulldozers, keep these points in mind:

- Keep bulldozers out of streambeds, even dry ones. Keep firelines that cross watercourses to an absolute minimum. If you have to involve streambeds, pick locations with gentle approaches that can be cleaned easily during rehabilitation. For guidelines, use the local forest practice rules.

- Keep bulldozers out of riparian zones.
- If near an archaeologically sensitive area, ask for a specialist to assist in fireline placement.
- Construct fireline in such a way that it can be easily waterbarred later.
- Construct your fireline along a ridge top if possible. The best places for bulldozer-constructed firelines are on ridge tops. The worst places are on the mid-slope or in the bottom of a drainage.

Keep bulldozers out of riparian zones.

Bulldozers Working Together - Generally speaking, using more than two bulldozers on a specific section of line may be overkill. It is best to work bulldozers in tandem, with one "pioneering" and the other widening and cleaning up the fireline. If one bulldozer is larger than the other, have the larger one lead. The smaller unit can follow up, finalizing the fireline. Additional bulldozers may be needed in heavier fuels or when extensive safety zone construction is needed (Figure 10.43).

Bulldozers and Engines - Bulldozers and engines can support each other in several ways. If bulldozers are constructing the primary fireline, an engine company can follow up, firing and

It is most effective when two bulldozers work together.

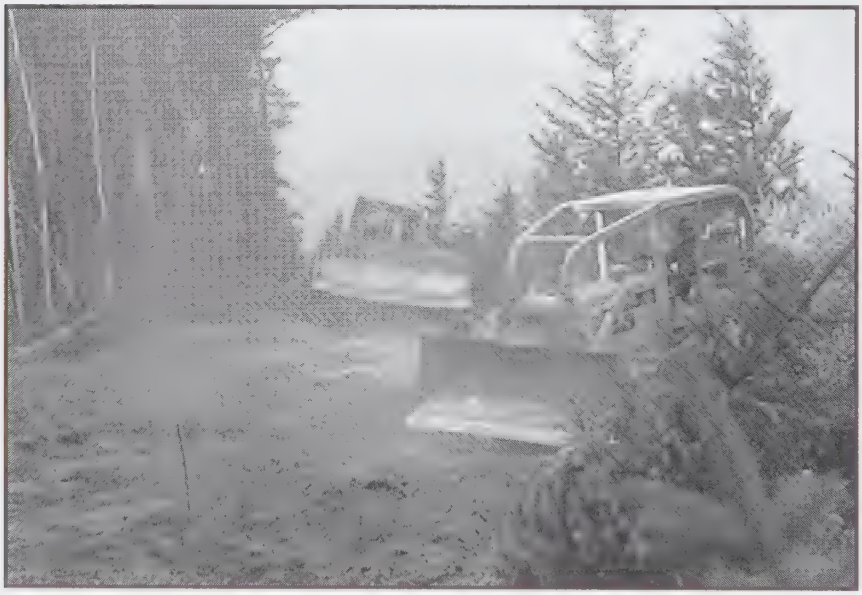


Figure 10.43 Bulldozers work well together. The first machine "pioneers" the fireline and the second follows up and cleans up the fireline.

holding the line. If the engine company is in a mobile attack, a bulldozer can follow up and cold trail the fireline.

Bulldozers and Handcrews - Handcrews can be used to provide support to bulldozer operations. They can fire and hold the bulldozer-constructed line. They can construct sections of fireline where the bulldozer cannot or should not work (Figure 10.44). Cautions: You should always ensure that there is some distance between the crew members and the bulldozer, and that bulldozer operators can see the crew members.

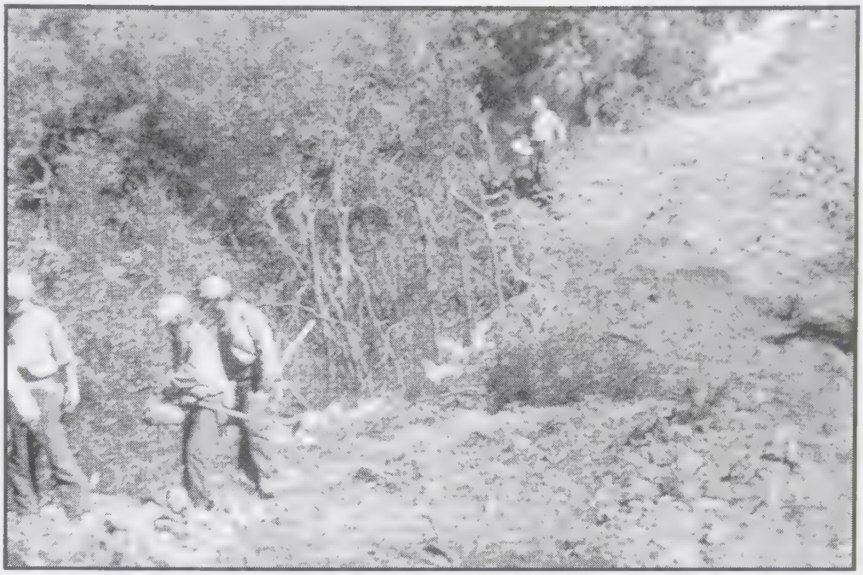


Figure 10.44 Bulldozer-constructed fireline usually has to be fired.

Bulldozers and Aircraft - Bulldozers can be put to good use following up on retardant drops. They are particularly useful when aircraft (airtankers and waterdropping helicopters) have been used to cool fuels or slow the fire's spread.

Use airtankers to knock down the fire, and bulldozers to follow up with line construction.

Make every effort to match the right bulldozer and experienced operator to the task. You'll be lucky to have time to complete a job once. Don't expect to have the time to redo things that were done wrong.

Handcrews

Handcrews can do many of the things a bulldozer can do, but with much less speed and brute force. Handcrews can be used to:

- Construct fireline.
- Conduct burning operations.
- Deploy hoselays.
- Cut blackline and mop up hotspots.
- Construct helispots.
- Rehabilitate fireline and pick up hoselays.
- Provide various logistical support functions.

As is the case with engines, not every handcrew is created equal. The productivity of a handcrew is directly related to the capabilities of the crew leader, the crew's level of training, and most importantly, the crew's motivation and morale. Some very highly trained crews may be non-producers if they want to be.

A crew is only as good as its leadership, motivation, and morale.

There are several types of crews that may be used in wildland firefighting. Under the Incident Command System, crews are classified based on their capabilities:

Type 1 crews are highly trained, with full-time leadership. These crews are very mobile, fully equipped, and prepared to take on any fireline assignment. Hotshot crews and some other similar crews, operated by various state and county fire agencies, qualify as Type 1 crews. (While there are some who feel that Hotshot crews are the only real Type 1 crews, there are actually other crews who qualify for this designation.)

Type 2 crews are not as mobile and usually not as well trained as Type 1 crews, but they are still very capable. Some of the more common Type 2 crews are made up of federal agency personnel, properly trained military personnel, organized pickup labor, and inmate firefighting personnel.

Mixing of Crews - There are several reasons why you shouldn't mix different types of crews on the fireline or in the rest areas. Some of the prime reasons are:

Try not to mix crew types when possible.

- Differences in levels of training and experience.
- Differences in pay scales.
- Differences in agency policies.
- Historical rivalries (native crews) - Some tribal rivalries go back hundreds of years. You may as well minimize potential conflicts.
- Custodial differences and security (inmates and juvenile crews) - If inmate or juvenile crews are on the fire, don't ever mix them with any other groups. Work, feed, and sleep them in different places. The custodial officers can help with this.

Crew Morale - Don't ever underestimate the impact crew morale can have on productivity. A genuine effort on your part to treat the crews well and with respect will reap benefits. One of the best ways to improve morale is to ensure that the crews are well fed. **Handcrews perform hard physical labor, and function better when well fed.** Some of the other factors that can affect morale are:

- **Crew conflicts and grievances** - Deal fairly and promptly with all grievances. Ensure that the crew/individual grievance is brought to the attention of the proper authorities, and to the extent possible, resolved satisfactorily.
- **Inequality of crew benefits** - Ensure that timekeeping is accurate and equitable. Make sure that all of the crews are treated alike.
- **Differences in dietary preferences** - Some firefighters may have special dietary requirements; you will have to take these into consideration, or you will have problems.
- **Mop-up operations** - Everyone wants to be on hot line, where the action is. But mop-up is very important and everyone has to be involved. Ensure that every crew member knows the importance of mop-up and knows how to do it effectively. Ensure that crews are provided the proper equipment. Also, rotate crews so that everyone gets involved in a variety of tasks.

Crews work best when they are well fed.

When developing a plan that includes the use of handcrews, be sure to match the crew's training and capabilities to the task at hand. Don't put crews in positions that may endanger them. Consider such things as fireline hazards, type of assignment (hot line, mop-up, etc.), fatigue, the possibility of heat-related problems, length of shift, and the level of leadership.

Firefighting Aircraft

Airtankers and helicopters play a vital role in wildland firefighting. However, they can be very expensive and not very cost effective if not used properly. Airtankers are single-purpose aircraft—they can only deliver retardant. Helicopters are more versatile. They can move personnel and equipment to remote locations, drop water or retardant, provide an excellent platform for reconnaissance, and provide emergency transportation of sick and injured firefighters. An air attack officer coordinates the air operations so aircraft don't fly into one another. The air attack officer can also be your eyes in the sky and give you very important intelligence on your fire and the progress of efforts to control it.

Aircraft are very effective. They are also very expensive.

Airtankers

Airtankers are most effective when used on initial attack. They can move quickly and make a swift strike while the fire is small. They can also be used effectively on large operations, but the larger the fire, the less dramatic their impact.

Airtankers are most effective during initial attack.

Airtanker drops are used to slow or hold down the fire's spread until ground forces can arrive and construct the final fireline. Never consider a retardant line as final; always follow it up with some type of ground action.

Airtankers can provide direct or indirect attack support (Figure 10.45). In a direct attack, airtankers can:

- Attack the head to slow it down.
- Attack the flanks, allowing ground forces to quickly follow up.

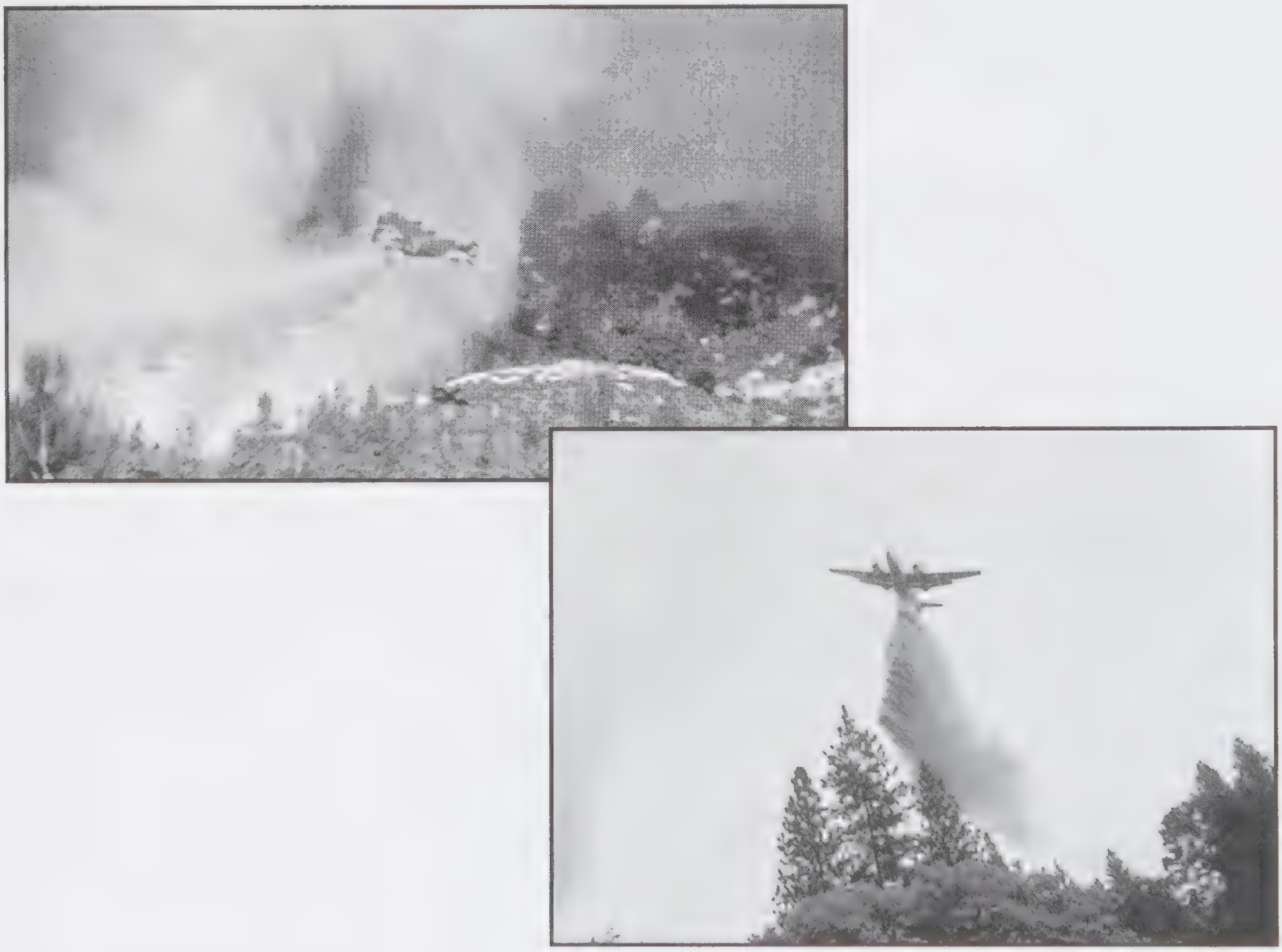


Figure 10.45 Airtankers have only one purpose, to drop retardant. They are most effective on initial attack fires.

- Attack spot fires or slopovers.
- Attack and hold critical areas like ridge tops and saddles.
- Protect structures or critical sites until ground forces can arrive.

Follow up airtanker drops with ground forces.

In an indirect attack, airtankers can:

- Pretreat fuels ahead of the fire in an effort to slow it down.
- Pretreat fireline that will be used for backfiring or burning out.
- Reinforce existing control lines.

Communication with airtanker pilots is critical. You have an obligation to warn them of any power or telephone lines in the area, any unusually tall trees or snags, or any other hazard that may put them in danger. In addition, without reliable communications with airtanker pilots, you cannot convey your requests/plans to them, and they cannot inform you of important observations made from their vantage point.

Warn pilots of tall trees or snags.

There are also safety considerations for forces on the ground. Not only is being hit by a drop of retardant unpleasant, but if the airtanker is low and fast when it drops several tons of retardant, it can cause serious damage or injury. The following are several safety points to consider if there are going to be airtankers on your fire:

- Be sure that the ground forces know that an airtanker drop is coming. Some of the newer airtankers are very quiet. They can be on you before you know it.
- If time allows, move firefighting personnel away from the target zone. This is especially true if the drop is to be made on a ridgeline or in an area where there are snags that might break under the force of the drop.
- If you cannot move ground personnel out of the area, be sure to tell the pilot that people are in the area. With this information, the pilot can adjust the height of the drop to ensure that all forward motion of the retardant has stopped before it hits the fuel.
- Remember that the retardant is very slippery.
- Be on the alert for an increased level of fire behavior near the drop area. The air coming off the wing tips can cause erratic winds on the ground.

If you can, move people out of an area before aircraft drop in an area.

After the drop, communicate the results to the pilot. Discuss your objectives for subsequent drops, as well as any information which may help the pilot accurately hit desired targets.

If you don't need airtankers, release them.

There may be times when the use of airtankers is not really accomplishing anything. If this is the case, put them on hold or release them. Don't be tempted to continue to fly the airtankers for public relations. We are all impressed with the drama of airtankers making drops on a fire. And sometimes firefighters are concerned that the public may blame any problems on failure to continue using aircraft. But, if you know they aren't necessary, shut the aircraft down. You can get them back later if you need them. However, you might want to hold one in orbit while you are doing some critical action, like firing a section of line, so that the airtanker can take quick action on any spot fires.

The pilot of the airtanker may have a better plan.

Once again, be sure that you tell airtanker pilots exactly what you want, and make sure that they understand. Their view of the fire is so much different than yours. What you see as critical may not be what they see as critical. Rely on them for information. The pilots know what they do best—they may be in a position to advise you on what would be the best target.

Helicopters

Helicopters are very versatile.

As stated earlier, helicopters are very versatile. They are sometimes thought of as jeeps with wings. Some of the unique capabilities of a helicopter are as follows:

- **Helitack** - When a small crew of highly trained and experienced firefighters are teamed up with a helicopter, they can be a very effective initial attack tool. Don't feel you should restrict their use to remote areas. They can be effective almost anywhere they can land.
- **Water or retardant delivery** - Helicopters are very effective water delivery tools. They can usually fill up at the closest water source, cutting down on the turn around time of an airtanker, which must return to base. They can usually place their drop much more accurately than an airtanker (Figure 10.46).
- **Transportation** - If you have to move people or equipment to remote locations, the helicopter may be right for the job.
- **Reconnaissance and mapping** - The best view of a wildland fire is usually from the air. Since a helicopter can move

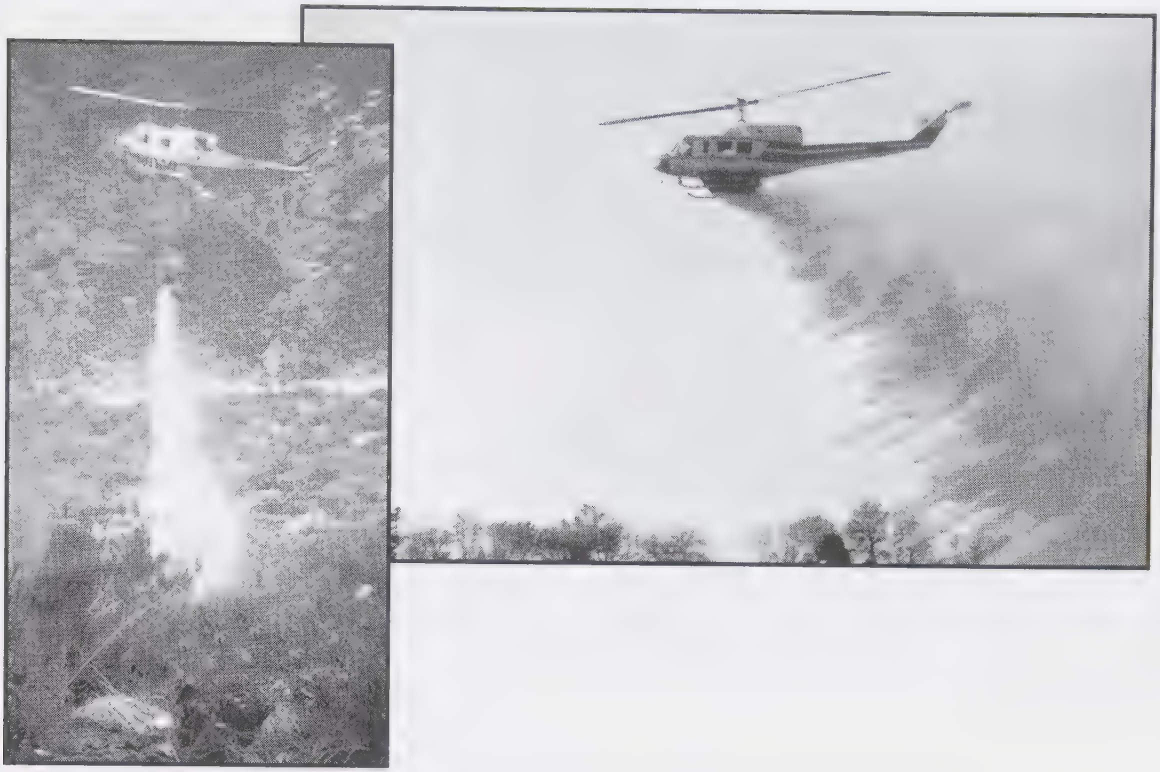


Figure 10.46 Helicopters are the most versatile of the firefighting aircraft.

around slowly, or even hover over a spot for some time, it is a perfect platform from which to view and map the fire. However, if the smoke is thick or there is a heavy timber canopy, the view of the ground will be restricted.

- **Aerial ignition platform** - It is possible to equip a helicopter with a torch or other ignition device and use it for burning operations. A great deal of fire can be started quickly with such a tool—sometimes too much fire (Figure 10.47).
- **Infrared detection platform** - Wildland firefighters are using infrared imaging equipment more and more often. The helicopter is an excellent platform for using some of the hand-held infrared systems. Many helicopters are now equipped with FLIR (forward looking infrared) equipment. This is an excellent tactical operations support tool. Infrared detectors can assist in the location of spot fires. They can be used to map the fire perimeter and to scan a section of fireline to detect hotspots.
- **Medical evacuation** - Since helicopters can maneuver and land just about anywhere, they are especially useful for moving injured personnel to medical facilities. They also provide a very effective way to move advanced life-support personnel to the site of an injured person.

Develop plans that maximize the use of assigned helicopters.

Figure 10.47 Helicopters can sometimes start more fire than you can handle.

Air Attack Officer

The primary function of an air attack officer is that of an air traffic controller. The air attack officer is responsible for the safety of all of the aircraft assigned to the operation. The air attack officer can also do several things for you as a fire officer. He or she can:

- Provide a birds-eye view of the fire and provide vital intelligence on what the fire is doing and where it is going. You should rely on the air attack officer for this type of information.
- Plot the fire on a map and drop it to you on the ground.
- Look over the area to see if there are any spot fires or other fires nearby.
- Aid responding firefighting resources with access routes, water sources, etc.
- Request that the air space be closed to all non-related aircraft.

Figure 10.48 The air attack officer is the person who keeps air operations safe and is a good "set of eyes in the sky."

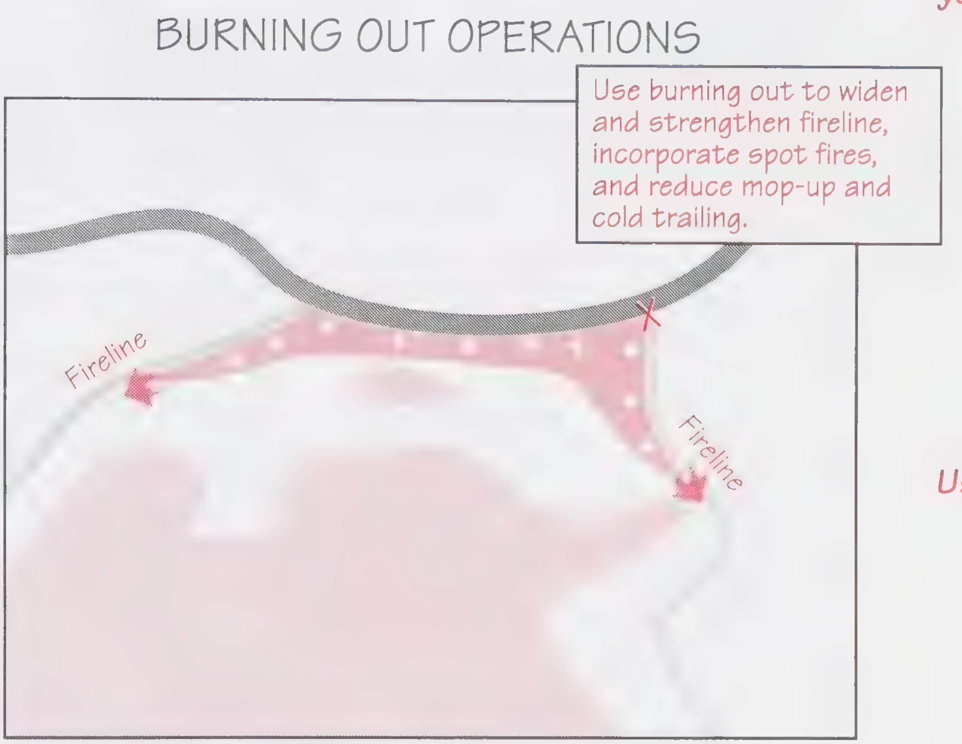
If an air attack officer is assigned to your fire, rely on him or her to coordinate the air operation (Figure 10.48). However, it is your responsibility to ensure that the air attack officer knows your plan and is following it. All too often, the ground forces and personnel operating the aircraft are not aware of what the other is doing, which can cause problems on the fireground. Take control! Air operations is working for you.

Use of Fire

The use of fire to fight fire is not new. It is a proven method to slow a fast burning fire, widen fireline, remove fuels from between the fire and the fireline, etc. However, using fire is not something a novice should be dealing with. Fire can be used in two ways:

Burning Out - Burning out is done to remove fuels between the fire and the fireline. It can also reduce mop-up time, incorporate spot fires into the fire perimeter, and widen fireline. Burning out can sometimes be used to create a safety zone (Figure 10.49).

The air attack officer is your eyes in the sky.


BURNING OUT OPERATIONS

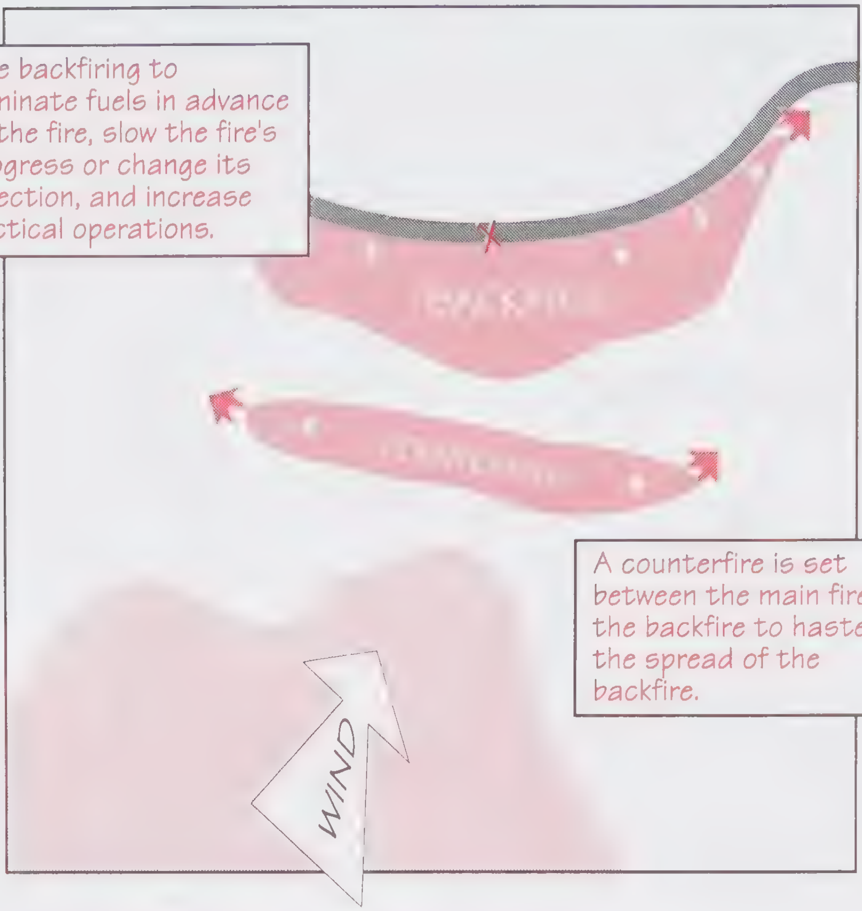
Use burning out to widen and strengthen fireline, incorporate spot fires, and reduce mop-up and cold trailing.

Figure 10.49 Burning out is used to clean up or widen fireline.

Use fire to fight fire.

Backfiring - A backfire is an indirect attack tactic used to slow a fast burning fire. A backfire is set ahead of the main fire in such a way that indrafts to the main fire push the backfire toward the main fire. This can reduce the fuel available to the main fire under controlled circumstances. This tactic has to be well timed and coordinated with other operations on the fire. Backfires are used when it is too dangerous or otherwise impossible to directly attack the fire (e.g., heavy fuels, extreme fire behavior), or to buy time until sufficient forces are available. A properly executed backfire can slow or even turn a fast running fire. The decision to backfire is one that is normally made by the Operations Section Chief or Incident Commander (Figure 10.50).

Backfiring is not for the inexperienced firefighter.


BACKFIRING OPERATIONS

Use backfiring to eliminate fuels in advance of the fire, slow the fire's progress or change its direction, and increase tactical operations.

A counterfire is set between the main fire and the backfire to hasten the spread of the backfire.

A backfire is set in such a way, that the main fire draws the backfire toward it.

Figure 10.50 Backfiring is a special type of firing operation.

There are several firing patterns that can be used when backfiring. Each one of these firing patterns has been developed to meet a specific need. They are as follows:

- **Backing fire** - A low intensity fire is allowed to back into the wind from an established fireline or barrier. This is a slow, time consuming technique, but it is one of the safest ways to use fire (Figure 10.51). Some of the hazards and drawbacks of using backing fire are the possibility of wind shifts, spotting, and rolling materials and the amount of time this method takes.

A backing fire is a low intensity fire.

- **Flanking fire** - A flanking fire is set along a control line parallel to the wind and allowed to spread at right angles to, and towards, the main fire (Figure 10.52). This type of burning is a little more intense because the control fire is generally burning with, rather than against, the wind. The hazards of a flanking fire include spotting potential and wind shifts.

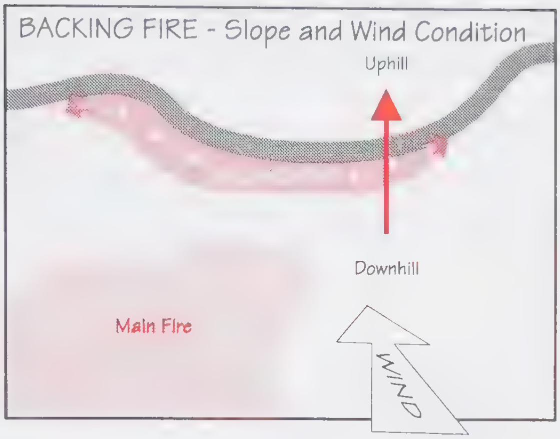

BACKING FIRE - Slope and Wind Condition
Uphill
Downhill
Main Fire
WIND

Figure 10.51 Backing fire is slow, but easily controlled.

- **Head firing -** When employing a head firing pattern, a fire is ignited at a control line and allowed to burn with the wind (Figure 10.53). This can result in a very intense fire. This technique may be useful if a wind shift is expected and you want to strengthen your control lines quickly.

When working a flanking fire, watch for spot fires and the hazards of a shifting wind.

- **Spot firing -** When using a spot firing technique, spots of fire, rather than strips, are ignited. This method is sometimes used when ignition is being done from the air.
- **Strip firing -** The strip firing technique is used when you want to widen a fireline quickly. In this firing pattern, fire is set in strips parallel to the fireline (Figure 10.54). With close coordination of the firefighters doing the firing, the intensity of this type of firing can be controlled. If several firefighters are used to light several strips of fire at the same

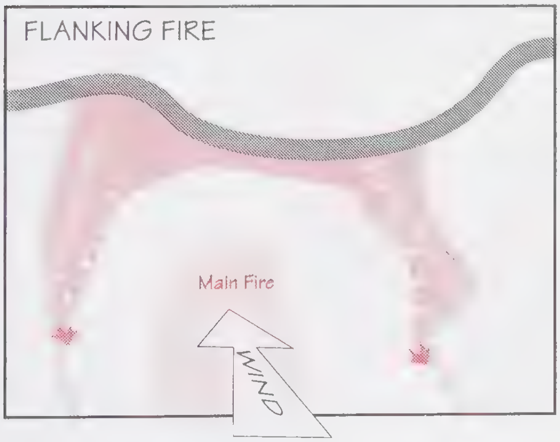

FLANKING FIRE
Main Fire
WIND

Figure 10.52 Flanking fire is used along the flanks of the fire. The wind is more of a factor in this method of burning. Flanking fires usually burn with a little more intensity than a backing fire.

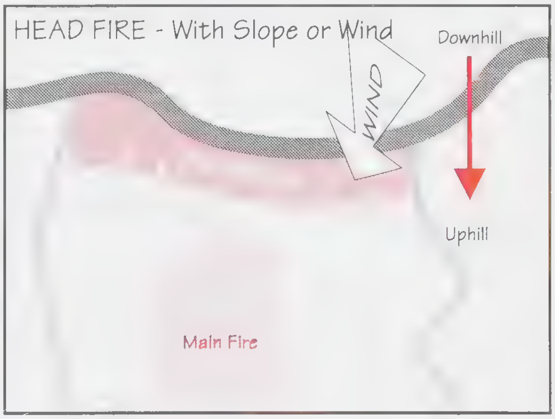

HEAD FIRE - With Slope or Wind
Downhill
WIND
Uphill
Main Fire

Figure 10.53 Head firing allows the fire to burn with the wind.

Strip firing is the most common firing scheme.

time, the "1-2-3" firing scheme should be used. The direction of slope and wind dictate the sequence of burning (Figure 10.55).

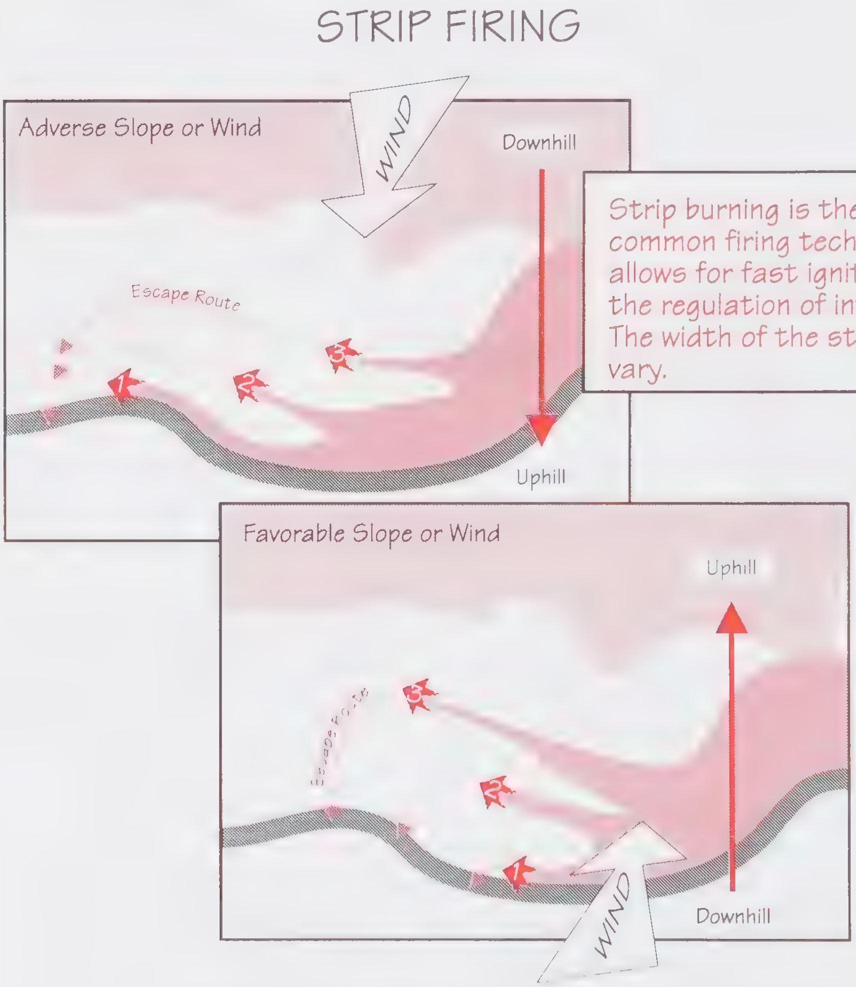
Use ring firing to protect structures.

- **Ring firing -** This type of firing is used when you are trying to save a valuable resource like a structure, or a historic or archeological site. This method of firing isn't anchored by the fireline. It is designed to create an unburned island (Figure 10.56).

There are several other firing techniques, but they are not commonly used and require very experienced people in order to be used safely and properly.

The key to a successful burning operation is how well you regulate the heat. If your firing operation burns with low intensity, you may not be getting a clean enough burn and the main fire

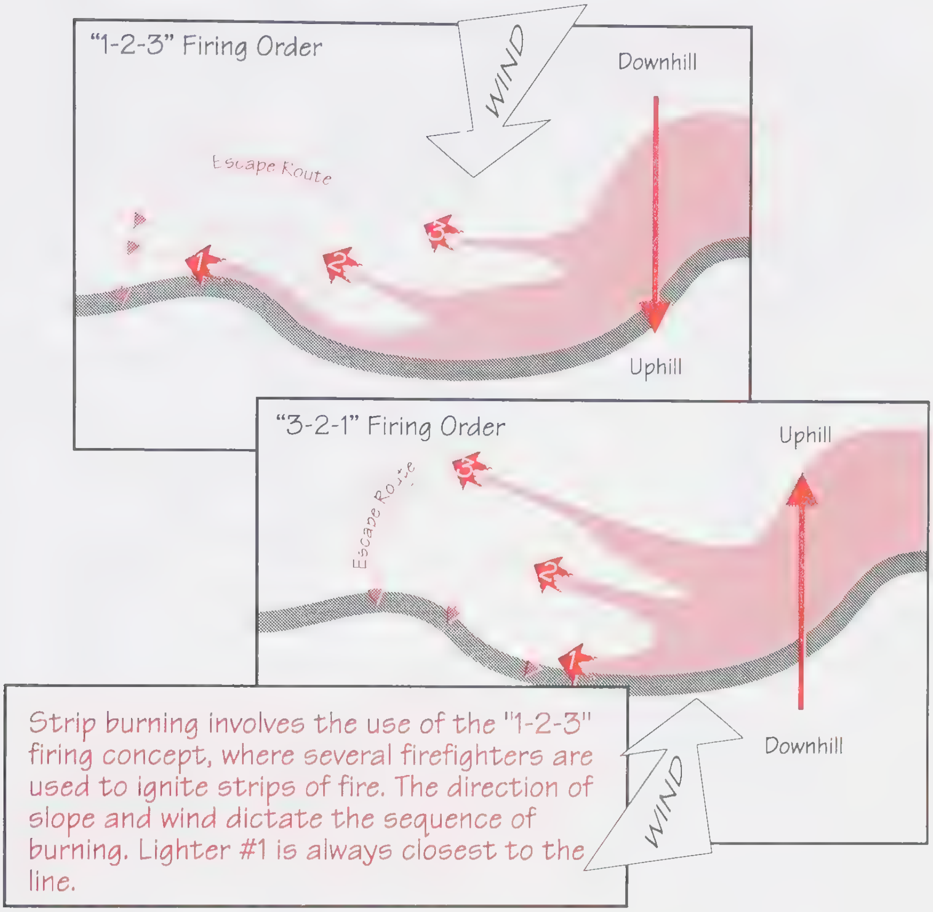
Use strip firing to widen fireline.


STRIP FIRING
Adverse Slope or Wind
WIND
Downhill
Escape Route
3
2
1
Uphill
Favorable Slope or Wind
Uphill
Escape Route
3
2
1
WIND
Downhill

Strip burning is the most common firing technique. It allows for fast ignition and the regulation of intensity. The width of the strips can vary.

Figure 10.54 Strip firing is used when you need to widen fireline quickly.

THE "1-2-3" FIRING CONCEPTS



Strip burning involves the use of the "1-2-3" firing concept, where several firefighters are used to ignite strips of fire. The direction of slope and wind dictate the sequence of burning. Lighter #1 is always closest to the line.

The firing order is dictated by the direction of slope and wind.

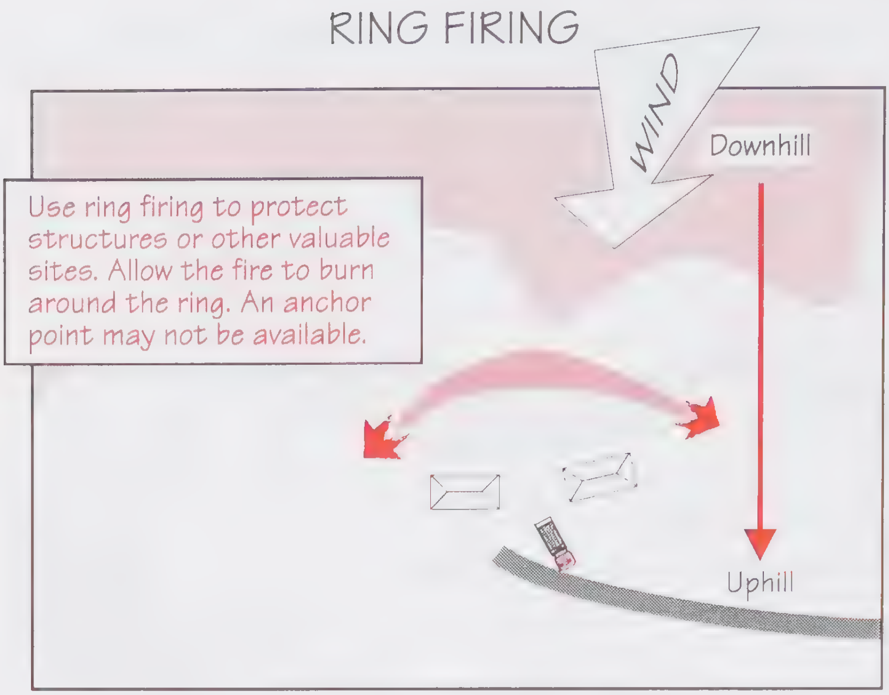
Figure 10.55 The direction of the wind and slope dictate the sequence of burning. Ensure that all of those involved understand the escape routes.

could break through your line. Conversely, you could misjudge the conditions and start a real "barn burner," adding to your problems by adding to the intensity of the main fire.

Don't start more fire than you can handle.

Some general rules for firing operations are as follows:

- Always begin firing from an anchor point (Except ring firing).
- Begin at the head, working down the flanks to the heel if you can.
- Burn downhill when you can.
- Burn from the back side of ridges (not the top) when you can.
- Burn into saddles simultaneously from both directions.
- Adjust firing to fit the situation.
- If conditions are favorable, fire without delay; later may be too late.



Use ring firing to protect structures or other valuable sites. Allow the fire to burn around the ring. An anchor point may not be available.

Figure 10.56 Ring firing is used when you need to protect a structure or other significant site.

Use ring firing to move the main fire around the structures.

- Fire short sections of line so that if you have a problem, you have the best chance of controlling it.
- The rate of firing should be consistent with your ability to hold it. Don't introduce more fire than your forces can handle.
- Fire around structures first before firing out control lines.

There are some things that will affect any firing operation. Consider the following problems as warning signs:

- There are sharp doglegs or hooks in the control line to be fired. Burn them first to reduce the spotting potential (Figure 10.57).
- The fireline is in a poor location (e.g., it is mid-slope and hasn't been trenched), or there are heavy fuels close to the line (Figure 10.58).
- The weather is likely to change. In this case, you may have to adjust or delay the firing schedule (Figure 10.59).
- There are structures or other valuable improvements in the area. In this case, you may have to change the plan or take actions to make the structures safe (Figure 10.60).
- The fuel type varies (Figure 10.61).
- You will be firing in box canyons or through draws (Figure 10.62).

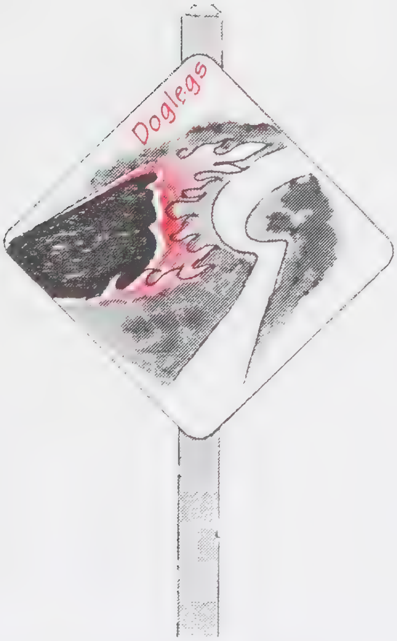


Figure 10.57 Doglegs and hooks in the control line can cause trouble.

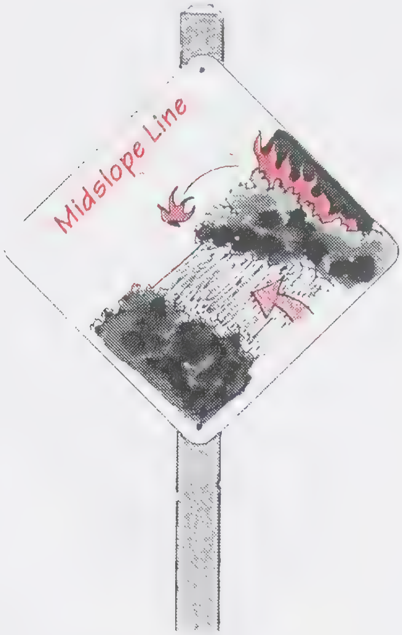


Figure 10.58 Fireline is mid-slope.

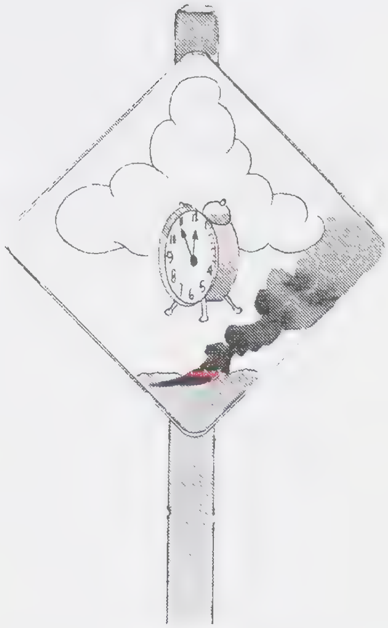


Figure 10.59 Time is critical because the weather is changing.

Be careful when firing mid-slope fireline.

Time your firing operations to take into consideration favorable weather conditions.

- The firing pattern is wrong for the conditions; there may be erratic fire behavior or firefighting personnel may be potentially endangered (Figure 10.63).

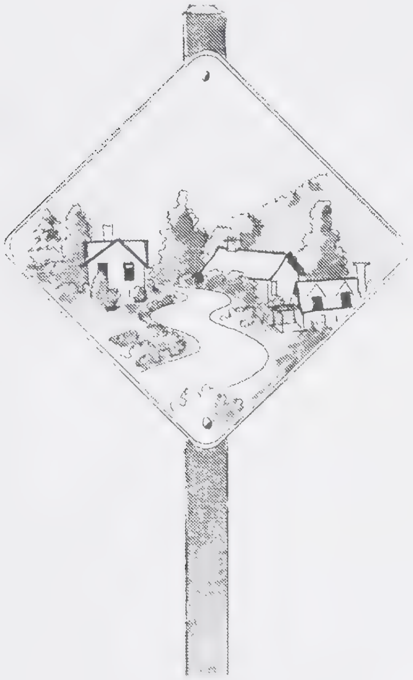


Figure 10.60 Structures are in the area.

If the conditions are unfavorable, the winds are against you, or if you have to fire in a canyon, get an expert who has had special training in dealing with these conditions. There are techniques that can be used in these situations, but you need an expert to advise and assist you.

The decision to use fire in your plan should not be made casually. Several of these techniques take special

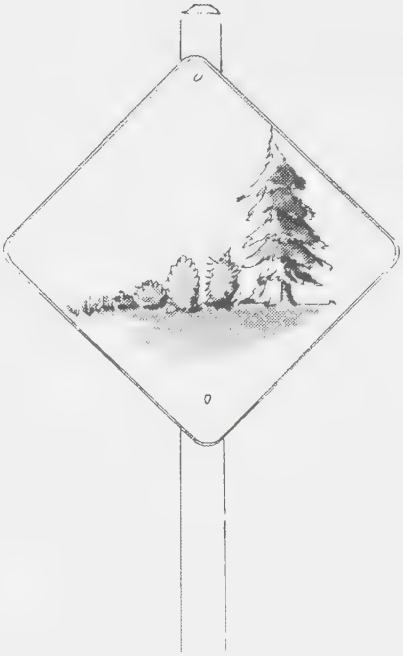


Figure 10.61 The fuel type varies.

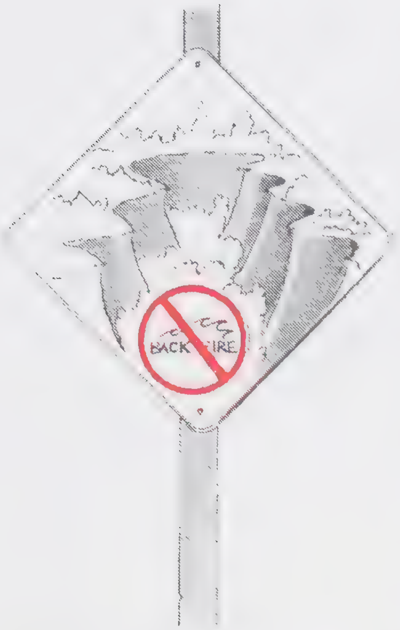


Figure 10.62 Trying to fire in a box canyon.

timing and coordination. Unless these techniques are used cautiously and skillfully, you could turn a good tool into a real disaster. Once you introduce your own fire, you change the dynamics of the whole event. Think out your plan and what it will do to the main fire before you light the match or fuzee.

Special note: There are laws in some areas prohibiting the use of firing operations. In some areas, there are laws which require firefighters to pay damages if a firing operation escapes; in other areas firefighters are protected from suits. In some states, the permission of the private land owner is needed. Know the local laws (Figure 10.64).

Figure 10.63 Firing pattern is wrong for the conditions.

Use the firing pattern that matches the conditions. The wrong method may spell disaster.

Organizing the Incident

Your firefighting efforts are only going to be as good as your organization, unless you plan on doing all of the firefighting yourself. Your first actions after size up are to develop a plan, set up an organization, and determine your resource needs. The following information regarding developing an organization is discussed in greater detail in Chapter 7.

Command

Who are you working for? Be certain that you, and the people working for you, know who you report to. This is something that should never be in doubt. There have been cases where it was not clear who was in charge. This can lead to some real operational problems and hard feelings. Make sure that if command changes on your fire, it is announced on the radio and the dispatch office is informed.

If your fire isn't organized, you may have two disasters to manage.

Transferring Command - It is commonplace for command to be transferred when an incident is growing in complexity. If a ranking officer assumes command, the fire officer should not take this as a sign of lack of confidence. It is just a way to ensure that the most experienced person is in charge and responsible for the overall suppression activities.

The transfer of command should not be a big deal.

Unified Command - If the fire is in an area where there is a shared suppression responsibility, establish a unified command immediately. This will facilitate the establishment of a single action plan and common communications channels. Usually, the structural firefighting personnel will protect the structures, while the wildland forces will work toward containing and controlling the fire.

If there is more than one agency with responsibilities for the fire, establish a unified command.

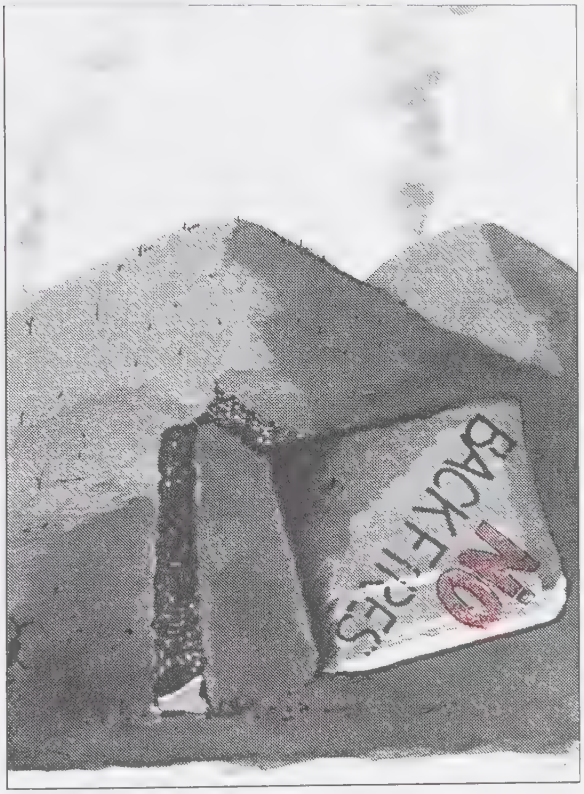


Figure 10.64 In some areas you are prohibited by law from using fire as a means of control. Know if the law allows firing before you light the torch.

Divisions or Groups

If the fire is anything but a spot fire that will be controlled quickly, your plan should include divisions. Developing an organizational structure that can implement your plan and stay ahead of a fire is one of the first things a wise Incident Commander does.

Think divisions.

A division is a geographical area of a fire. There are no hard and fast rules for how big a division should be. In general, it should be no more complex than one experienced person can successfully manage. Determine practical boundaries and be sure they are clearly understood. A group is a functional area of responsibility (e.g., a structural protection group or a bulldozer group). Establish groups as specific tasks or functions require.

Divisions are geographic; Groups are for tasks or functions.

Ensure that the Division/Group Supervisors assigned to the incident are qualified. (Pay attention to the troops if they express concerns.) More than any other position, the Division/Group Supervisors are the key to a successful operation. If necessary, replace inexperienced Division/Group Supervisors with people who are more qualified. However, do so in a manner which minimizes hard feelings or morale problems (Figure 10.65).

Don't make the size of the division too large.

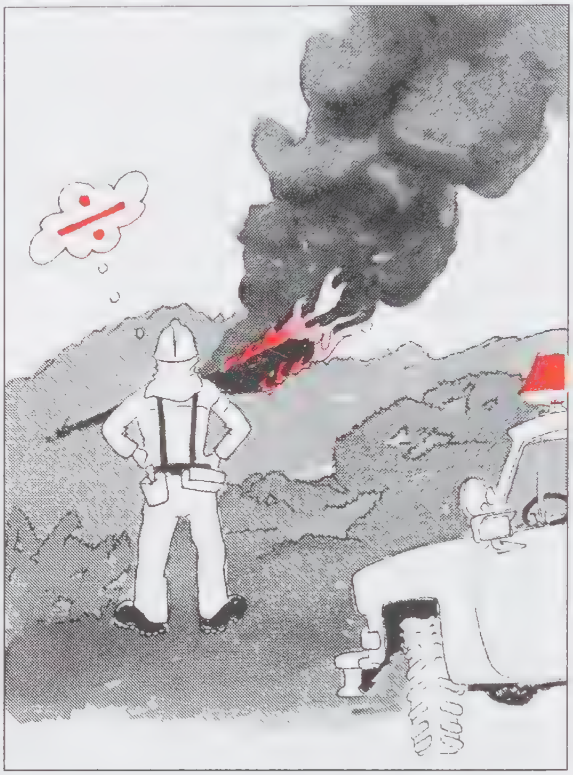


Figure 10.65 Even if you only have two engines fighting a small grass fire, think in terms of divisions. It will help if the fire goes beyond initial attack.

Establishing the Incident Command Post

Once committed to an operation that will last for more than an hour or so, the Incident Commander should select a site for the Incident Command Post (ICP). This will be the location from where the fire will be managed. The establishment of an ICP is most important to those who have to contact and communicate with the Incident Commander (Figure 10.66). Once an ICP is established, the Incident Commander should remain at the ICP except as needed to perform reconnaissance. The ICP should provide:

- **Safety** - It should be safe from the fire, out of the traffic, and away from potential civilian activity.
- **Shelter** - It should provide shelter from the weather, smoke, wind, etc.
- **Communications** - It should have both radio and telephone equipment available to the IC and key staff.
- **Room to Assemble** - It should be large enough to provide working areas for key staff, and briefing space for firefighting personnel and the media. Don't forget to provide space for cooperating agencies and for adequate parking.
- **Convenience** - It should have electrical power, water, and sanitation facilities.

Locations such as fire stations, schools, community halls, fairgrounds, parks, and campgrounds generally make good ICP sites. Gather the key players at the ICP as soon as possible and get them working together.

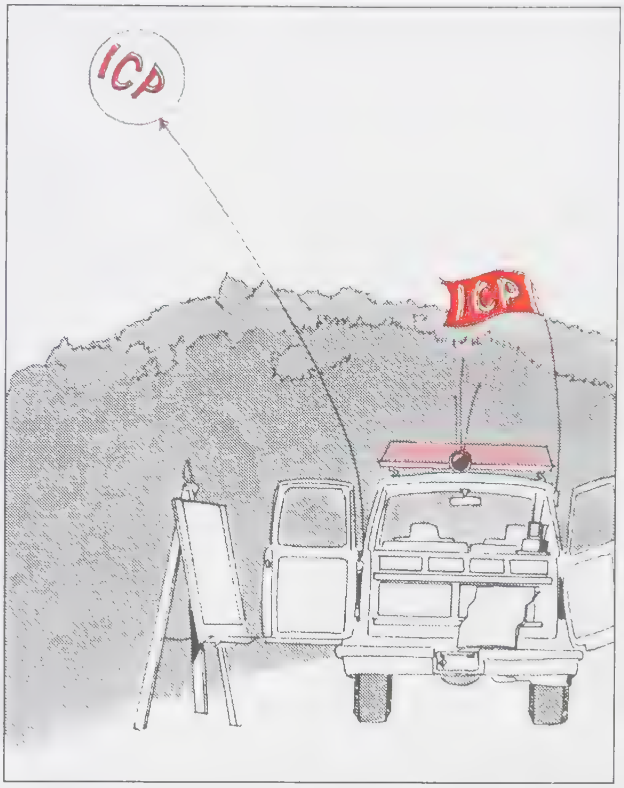


Figure 10.66 This is a well-marked incident command post!

Staging

Staging provides a place for all responding units to report. By holding resources in a staging area, you can reconfirm what equipment and people have arrived at the fire and manage their appropriate assignment on the fire (Figure 10.67).

Need for Support Functions

Support functions are not limited to logistics, food, gas, and fire hose. These are important, but two of the first support functions that should be established are the Situation and Resource Status units within the Planning Section. You can't plan or manage the incident if you don't have accurate information on what is happening, and where the resources are assigned and currently working. If the fire is running and you will be there a couple of days, you should start developing the plan for the next operational period as soon as possible. You can't wait until you actually need them to order the personnel and equipment needed for the next shift or operational period. Make it a point to tell Operations and

Use staging to manage the flow of the resources.

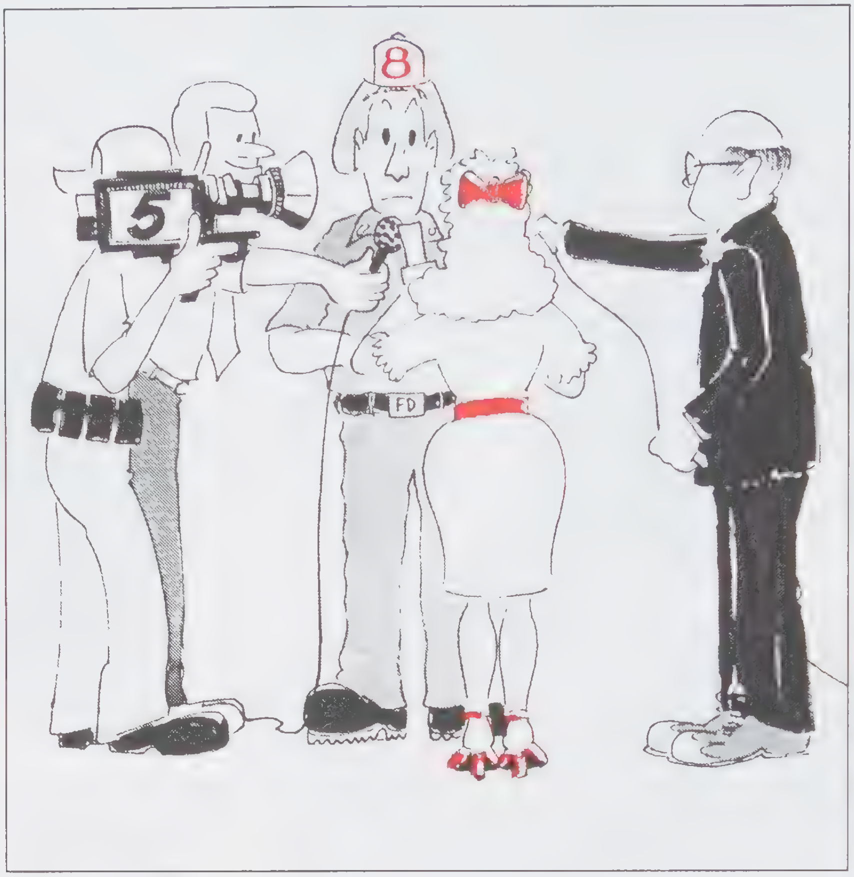


Figure 10.67 Set up a staging area as soon as you can. It will aid dispatch, the incoming equipment, and you.

The media must be dealt with.

Planning what you feel will be needed on each division during the next planning period. Be proactive!

Firefighters must be provided adequate drinking water and hot meals.

Another critical support function is the provision of hearty, nutritious meals. It is hopeful that all of the forces assigned to the fire can subsist on rations through at least one meal. If you expect the fire to be contained after dark, schedule the first hot meal for about midnight. This will give the firefighters time to strengthen the firelines, and for logistics personnel to prepare or arrange for a meal. There will be times when any hot food on the fireline is out of the question. If that is the case, do everything you can to provide the best nourishment possible. Be sure that personnel have plenty of water available to prevent dehydration and heat stroke.

Other support functions that may sometimes be necessary are:

Utility Companies - The power company should be advised immediately if there are downed lines so they can de-energize them. You may also need to consult with them regarding the advisability of completely shutting down the power in the area. The phone company can be very helpful by adding additional telephone service, as needed, for incident management functions.

Coordinate with supporting agencies.

Law Enforcement - You will need law enforcement to conduct evacuations, block roads, and to keep the fire scene secure.

Animal control - If you have a major fire running through an area, there will be dogs, cats, horses, and other animals to deal with. Notify and involve animal control as soon as you can.

Fire Information Officers - When there is smoke on the horizon, the media will be present. In most cases, fire information officers will be providing all of the contact with reporters. If fire information officers or command personnel are not available, you may have to answer media questions. Their presence may seem inconvenient when you are swamped with the details and problems of a major incident. However, as long as they don't interfere with your actions or put themselves or anyone else at risk, they have the right to be there.

The pressure from the media may be overwhelming.

Be courteous, professional, and helpful when dealing with the media. Only answer questions that deal with your area of responsibility. Provide factual information; never provide undocumented information. Never release the names of injured or deceased personnel or civilians.

Be prepared to answer the most commonly asked questions:

- How many homes have been lost?
- Where is the fire and where is it going?
- Are people being evacuated?
- Has anyone been hurt? (Remember, do not release names or other identifying information.)
- What started the fire?

Do not speculate or comment on the actions of others. Do not provide unsolicited comments. The media has been known to take off-the-cuff comments and print them as fact. You may be managing the best fire suppression operation in the history of the world, but if the media reports it was all screwed up, the public will believe it was all screwed up.

Incident Organization Worksheet

You need to begin keeping written documentation immediately upon your arrival on the fire. There are two main types of records you should keep. One is some form of written documentation of all operational aspects of the fire. The other record is a Unit Log which records events which will be important later for such things as cost apportionment.

The proper management of an incident involves some paper work.

One of the best tools available to you for organizing your incident is an Incident Briefing Form such as the ICS 201 or similar form.

Begin by listing the resources that are assigned or on order. Sketch the fire so that you can start visualizing the whole fire, not just the piece you can see. Place names in the various organizational boxes.

Establish an Operations Section that is capable of implementing the objectives and overall strategies, and that will be capable of managing the resources that have been ordered. As noted previously, on anything but a small spot fire, divide the fire into divisions. Appoint engine company officers as Division/Group Supervisors if you have to. Replace engine company officers with chief officers or other appropriate independent resources as soon as possible so that you can keep crews intact. If you have a fast moving fire that is threatening structures, you may want to establish a structure protection group.

Keep notes of key events.

Communications

Get communications under control. Request that dispatch designate command and tactical nets. On large or complex incidents, designate tactical nets for each division or group. Make sure traffic on the tactical net is conducted on simplex or car-to-car frequencies. Your ability to manage an incident will be severely hampered if your communications tools aren't working; in fact, you will be in violation of one of the Fire Orders. As you are organizing your fire, keep the radio communications capabilities of each resource in mind. There will be times when the radio systems of the firefighting resources will not be compatible. This is occurring more and more often with the advent of the 800 and 900 megahertz systems that are being used.

Under the Incident Command System, there are five radio nets. These nets are:

The radio communications system will often be overloaded.

- **Command** - The command net is used to communicate between the various command and general staff functions down to the Division/Group Supervisor level. This is an exclusive channel for command and control communications. It is not for general tactical operations.
- **Tactical** - The ability of the resources on a division to communicate with each other and with supervisory staff is critical to the success and safety of the operation. Tactical nets are used for tactical communications at the division or branch level. "Tac nets" may be established around agencies, geographical areas, or specific functions. On large operations, there will be several tactical nets assigned. The specific radio frequencies will be listed in the Incident Action Plan on the bottom of each Division Assignment List. Use the "tac net" to communicate with other equipment or personnel in your division.

Use cellular phones to communicate.

- **Support** - The support net is established for the purpose of handling status changes, requests for support needs, and communications which are not tactical or command functions. Use the support net to communicate to Incident Communications about changes in status, like "out of service mechanical" or "in incident base, off shift." If you need fuel, water, or food, you use the support net.
- **Air-to-Ground** - The air-to-ground net is used by the command structure to communicate with the incident Air Operations Group. It is an exclusive net for air-to-ground communications only. This net is critical during major fire operations where several tactical nets are in use. It is impossible for the air attack officer to monitor each and every "tac net." If ground forces need air support, they can switch to a specific air-to-ground frequency and request assistance.
- **Air Tactics** - The air-to-air net is the net used for tactical air operations. It is the net used by the airtankers and helicopters to communicate among themselves and with the Air Attack Officer. This net should never by used by ground forces. The only exception may be the communications between a helitack crew and its helicopter.

Cellular Phones - Cellular phones are becoming commonplace in most chief officers' vehicles, and the coverage is improving every day. Don't underestimate the value of cellular phones in your operation. As forces arrive at the incident, ask if the officers have cellular phones; make a note of the numbers and inform them that their phones may be backup/primary for communications.

Initial Attack to Extended Attack Transition

When does an initial attack end and extended fire attack actions begin? Initial attack is defined as the action of the personnel first assigned to an incident. Usually, this includes all resources that are part of the first alarm assignment. If the Incident Commander orders additional resources, by definition, the fire moves into extended attack. The real difference, however, is how the incident is organized. During the initial attack, you usually have not established divisions or logistical support, and do not usually have to deal with the news media, span of control, and sightseers.

Know when it is time to move your thinking from initial attack to extended operations.

The best way to deal with this very important transition is to always think extended attack. This means establishing an organizational structure and approaching the fire from a global perspective right from the beginning. As soon as it is apparent that the first alarm will not be successful, the Incident Commander should step back from focusing on the tactics of the firefight and begin to look at the overall management of the incident. This means developing a management organization and contingency plans to deal with unforeseen events for an extended period (Figure 10.68).

Looking at the big picture includes:

- **Life and Property Exposure Hazards** - Quickly identify the life and property exposures at risk. Determine the level of threat and prioritize each exposure. Provide adequate warning to endangered persons. If evacuation is necessary, order it in time so that it can be accomplished as safely as possible. Decide what resources will be necessary to protect those exposures that can be saved.

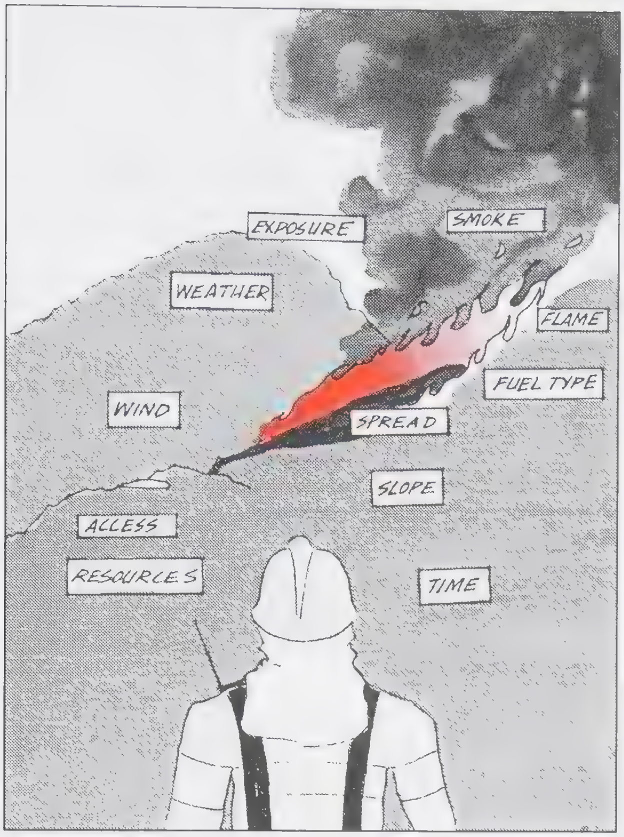


Figure 10.68 This fire officer is reviewing his "big picture" checklist.

- **Barriers** - Locate the natural or man-made barriers that are available and include them in your containment strategy. Consider backing off to these barriers, wherever possible, to reduce the overall effort. Identify barriers that may be available as secondary firelines.

Look at the big picture.

- **Strategy and Tactics** - Develop a strategy that extends to the end of the burning period. As you develop your objectives, consider values at risk, barriers, resources available, tactics, and costs. Communicate your plan to the resources at scene and to your dispatch office.

Plan ahead and designate a staging area.

- **Staging Area** - The next item of business is to establish a staging area. You should be prepared to deal with the resources you are expecting *before* they arrive. Select a staging area that is easily located and that will not add to the confusion on the fireground.
- **Resources needed and availability** - Determine what resources are needed to implement your plan. Build in a "reserve" that is available to respond to changing situations or unanticipated needs. Place a consolidated order as soon as possible. Stringing out requests is an indication that you don't have a plan. Don't just order firefighting resources; be sure to include the overhead needed to manage these resources. Request that all resources be dispatched to the staging area for check-in and assignment.

Remain flexible.

Remain flexible. Be constantly alert for changing conditions. Be prepared to respond and change your strategy and tactics when conditions warrant it.

Chapter 11 presents ten mock fire situations. Using the information in this chapter, document in detail how you would attack each of these fires.

11

Firefighting Situations

The fire scenarios in this chapter are designed to help you practice developing strategies and tactics using the information you have learned about weather, fuels, fire behavior, etc. Analyze these situations and write out one or two sets of strategies and tactics. These exercises will be most useful to you if you carry out your plans in some detail, including how your plan should change if conditions change. One or two possible plans for each fire are included, and if the situation is based on a real fire, some information is provided on how it was fought.

Do not read these proposed plans, developed by other seasoned fire officers, until you have completed your own. If you do, you will be passing up an opportunity to practice your own skills. You will see that there is more than one way to fight a fire, and the plans you develop may be just as valid as the ones proposed in this book.

In this chapter, you'll

- *Review several comprehensive fire scenarios.*
- *Practice developing strategies and tactics for the fires.*
- *Get to compare your plan(s) against those of other fire officers.*
- *Learn how to change your plan when conditions change.*
- *Learn that there is more than one way to deploy limited resources on the same fire.*

Firefighting Situation 1

You are a Fire Management Officer for a state forestry organization in the Pacific Northwest. You are responsible for the protection of over 200,000 acres of privately-owned timber. This had been a normal fire season, but in late August average temperatures increased significantly, and there are now several large fires burning in the area.

About half of the normal initial attack forces are committed to working fires. The weather forecast issued yesterday afternoon is as follows:

It is a hot August day; several large fires are burning in the area.

```
   NATIONAL WEATHER SERVICE
   FIRE WEATHER FORECAST
   3:00 PM PDT THURSDAY AUGUST 23

   DISCUSSION: THE UPPER LEVEL HIGH OVER THE
PACIFIC OCEAN WILL CONTINUE TO BRING WARM
DRY WEATHER TO THE AREA FOR THE NEXT SEVERAL
DAYS.

   TONIGHT...
     WEATHER: CLEAR AND WARM.
     LAL: 1
     TEMP/RH: LOW TEMPERATURES IN THE 60S
     WITH RH GENERALLY ABOVE 50%.
     WIND: SOUTHWEST TO WEST 5 TO 8 MPH

   FRIDAY...
     WEATHER: HOT AND DRY.
     LAL: 1
     TEMP/RH: HIGH TEMPERATURES IN THE 90S.
     MINIMUM HUMIDITY 15 - 20%.
     WIND: UP CANYON AFTERNOON WINDS 12 - 15
     MPH. WIND ACROSS RIDGES SOUTHWEST 20-
     22 MPH, GUSTING TO 25+.

   SATURDAY...
     CONTINUED HOT AND DRY
```

Situation: At 0900 hours, you hear a lookout reporting the weather. The temperature is 62°, relative humidity is 31%, the wind is southwest at 12 miles per hour, and the 10-hour fuel stick is 4%.

Temperatures will be in the 90s. The relative humidity will be in the teens.

Locally there are only six engines of all types and one bulldozer available. Aircraft will be limited, and handcrews will have a travel time of several hours.

At just after 1300 hours, a vehicle fire is reported near Cold Springs Hill. The Bald Mountain Lookout report puts the fire on Campbell Creek Road, 2 miles south of the "H" Line Road. The first alarm includes:

1 Fire Officer (this is you)
4 Engines (two Type 3s with four firefighters on each and two Type 2s with two local government firefighters on each engine).
1 Type 2 bulldozer
1 Air Attack
2 Type 2 Airtankers
2 Type 1 Handcrews

Aircraft will be in limited supply.

There is a vehicle fire in the Campbell Creek drainage.

The air attack arrives 35 minutes after the dispatch and reports a fire about 10 acres in size, spotting, and burning on both sides of Campbell Creek Road. The fire is burning in second-growth timber and slash. The air attack suggests that the first-due engine take action on fire moving west from the road and requests two additional airtankers. This request is denied; no additional airtankers are available.

The first engine arrives and takes action on the spot fire burning west of the road (Point A). One of the airtankers drops on the spot fire in the center of Section 7. You arrive at 1400 hours (at Point A) just as the air attack drops a map of the fire and the second engine (at Point B) is asking for instructions (Figure 11.1).

The fire is ten acres on both sides of the road.

You find the fire burning upslope, with 4- to 5-foot flame lengths. There is approximately a 5 mile-per-hour up-canyon wind (Figure 11.2). The next two engines, the two handcrews, and the bulldozer will arrive in the next 30 to 45 minutes at Point A.

You arrive and assume command.

You know that you should try to keep the fire from crossing the "H" Line Road (Point C to Point D) to keep the fire from getting into very steep, rough terrain. The road (Point F to Point I) will only be passable if opened up by a bulldozer. (There is a road not shown on the map between Points C and I).

You are briefed on the suppression actions and get a map from air attack.

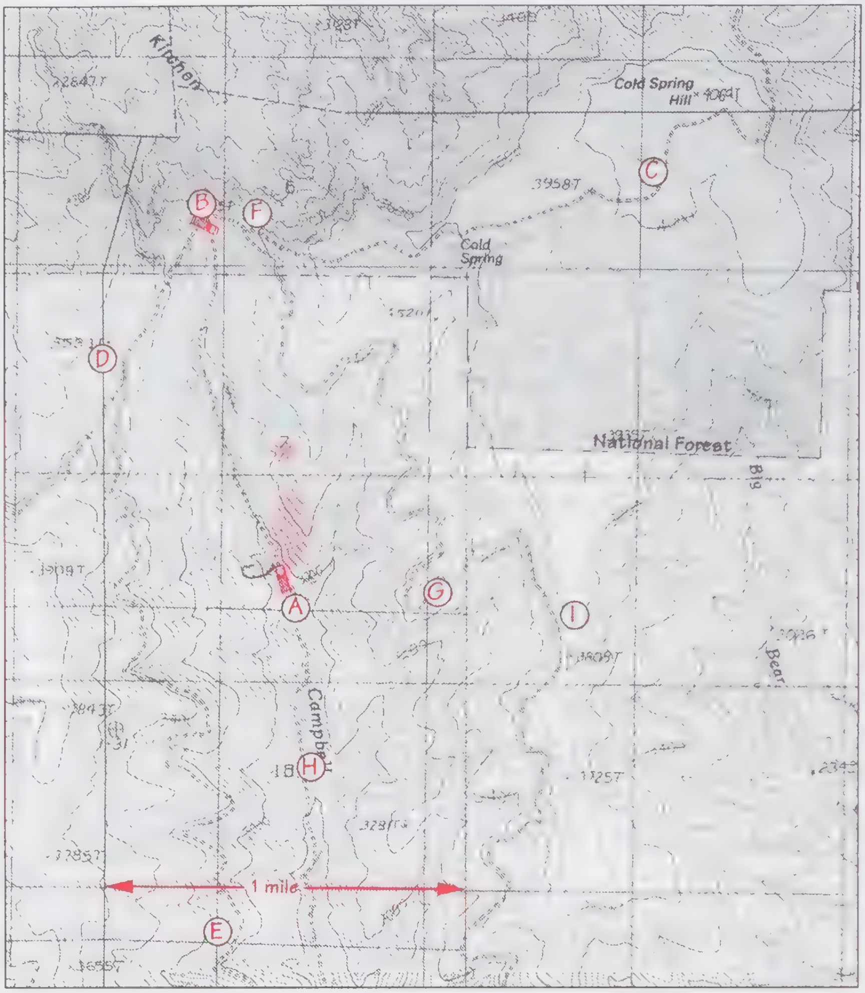

Kitchen
3887T
2847T
Cold Spring Hill 4064T
C
3958T
B
F
Cold Spring
D
National Forest
Big
3909T
G
A
I
3809T
Bear
Campbell
18
H
3257T
3281T
1 mile
E
3695T

Figure 11.1 This is the map prepared by the air attack and dropped to you on the ground near Point A.

You take the weather.

You take the weather: dry bulb temperature is 87°, wet bulb temperature is 60°, and the wind is up-canyon at about 8 miles per hour. The relative humidity and dew point table for this elevation says the relative humidity is 19%.

Solution Required: Assume the position of Incident Commander and start developing your action plan. Identify how you will complete each of the following tasks and why you made the decisions you did. Then compare your answers with the two solutions that follow:

- Assign the first alarm resources.
- Develop your objectives and action plan.
- Determine what additional resources, if any, are needed.
- Outline the plan to contain the fire.

Figure 11.2 This is what you see burning northeast from Campbell Creek Road.

Possible Solutions: Two possible solutions to this fire situation will be presented. In the first solution, the Incident Commander takes a conservative, direct attack on the fire. In the second scenario, the attack is much broader in nature, assuming a direct attack will be limited in success.

What objectives will be set?

Suppression Strategy 1 - Conservative direct attack.

The Incident Commander arrives and establishes the ICP at Point A. He directs Engine 1 and Engine 2 to attack the spot fire west of Campbell Creek Road. He then directs the air attack to assist Engine 1 and to drop the second load of retardant on this spot.

The "Campbell Creek IC" establishes the following incident objectives:

- Provide for the safety of firefighting personnel.
- Catch the spot fire west of Campbell Creek Road and keep fire spread to a minimum.
- Keep the fire from crossing Campbell Creek Road (between Points A and B).
- Keep the fire from crossing the upper road (between Points F and G).
- Keep the fire from crossing the "H" Line (Points B, F, and C).

The first objective is the spot fire west of the road.

The fire is divided into three divisions. Division A encompasses all activity west of Campbell Creek Road. Division B is on the right flank of the fire, and Division C is on the left flank. The fire officer on **Engine 1** is designated "Division A." **Engine 2** is also assigned to Division A. Their assignment is to contain and control the spot fire west of the road. **Engine 3** will be assigned to Division B to begin a hose lay, anchored at the road, up the right flank of the fire. They want to keep the fire from crossing Campbell Creek to the east. **Engine 4** will be assigned to patrol the Campbell Creek Road between the ICP and the "H" Line (Points A and B), ensuring the fire does not spot across it. "**Campbell Creek Air Attack**" is instructed to assist Division Supervisors as needed. He is also to provide regular reports on conditions (Figure 11.3).

Divide the fire into three divisions.

The remainder of the initial attack force will be assigned as follows: **Dozer 1** will be assigned to Division B, to construct fireline up the right flank toward the upper road (Points F and G). Once the road is reached, Dozer 1 is to open the road back toward the "H" Line (Point F). **Crew 1** will be assigned to Division A. **Crew 2** will be assigned to Division B, assisting in the hose lay and following up Dozer 1.

Start hose lay up the right flank.

The Incident Commander orders the following firefighting resources:

3 Type 2 water tenders
3 Handcrews (either Type 1 or 2)
1 Type 2 bulldozer
2 Type 3 engines
2 Type 4 engines
2 Division/Group Supervisors
2 Task Force Leaders
1 Staging Manager

Order additional resources.

These forces are to report to the Staging Area, a large log landing south of the ICP (Point H).

Most of the additional forces will be used to begin taking action on the left flank. This line will be a little tougher to construct. Most of it will be undercut, and the fuels will be thicker. The bulldozer will begin constructing line from the Campbell

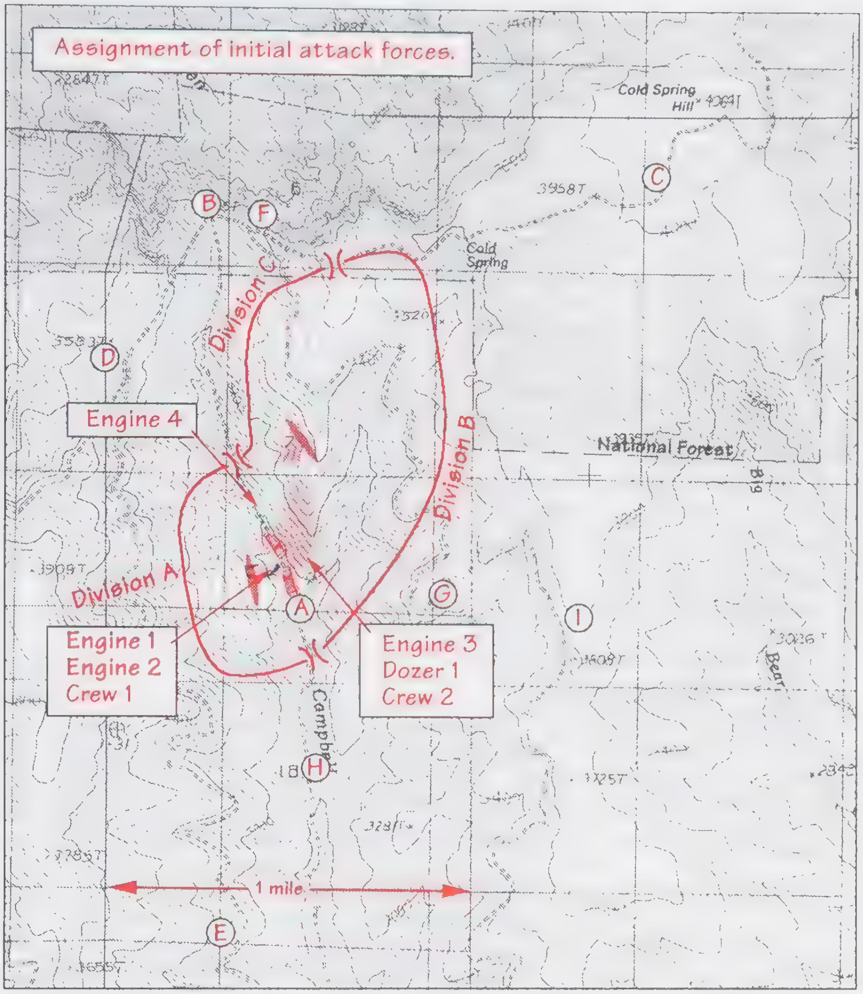

Assignment of initial attack forces.
Cold Spring Hill 4064T
3958T
Cold Spring
B
F
C
Division C
D
Engine 4
National Forest
Big
Division B
Division A
A
G
I
Engine 1
Engine 2
Crew 1
Engine 3
Dozer 1
Crew 2
3026T
Bear
Campbell
H
3257
3281T
1 mile
E

Figure 11.3 The fire is divided into three divisions. The first alarm assignment is deployed. The priority is to control the spot fire west of Campbell Creek Road. The next priority is on the right flank—keep the fire from crossing Campbell Creek to the east.

Use the airtankers to support ground operations.

Keep the fire from crossing Campbell Creek.

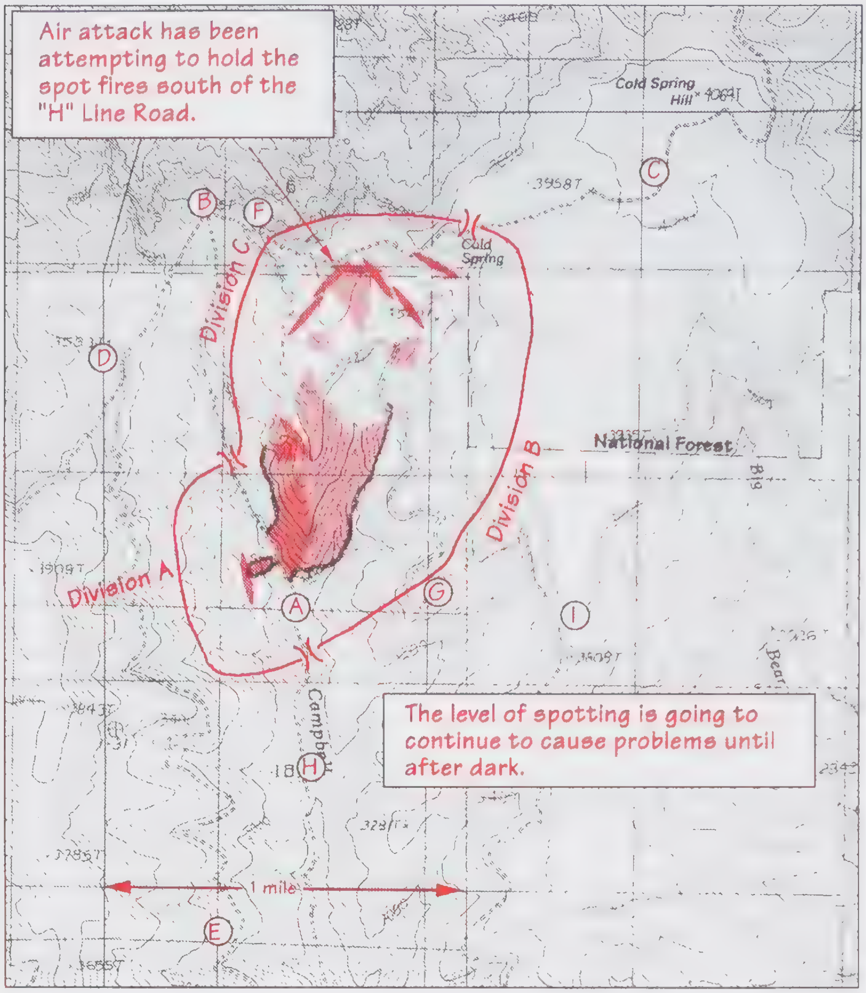
Creek Road up the left flank. When Dozer 1 finishes its assignment, it is to be "walked" back down Campbell Creek Road, where it will assist in constructing the fireline on Division C (Figure 11.4).

The IC will not allow any downhill, indirect line construction. With the spotting that has already occurred, the relative humidity below 20%, and the afternoon up-canyon winds picking up, safety has to be a concern.

Do not allow downhill line construction.

The fire continues to throw spot fires well ahead of the main fire.

Airtanker drops are used to slow and contain the spot fires.


Cold Spring Hill
4064T
3958T
C
B
F
Division C
Cold Spring
D
National Forest
Big
Division B
Division A
3909T
G
A
I
3608T
Bear
Campbell
H
18
3843T
3281T
2343
3785T
1 mile
E
3655T

Air attack has been attempting to hold the spot fires south of the "H" Line Road.

The level of spotting is going to continue to cause problems until after dark.

Figure 11.4 The fire has spotted well ahead of the main fire. Airtanker drops are being used to contain the spots, but this may not be successful. Division B is making good progress.

Suppression Strategy 2 - Direct attack with heavy reinforcement.

The objectives are a little different—a broader approach.

The "Campbell Creek IC" arrives at the incident and establishes the ICP at the origin of the fire (Point A). He organizes a three-division fire. Division A is that portion of the fire west of Campbell Creek Road. Division B will be the left flank, or north flank, from Campbell Creek Road. Division Z will be the right, or south flank, from Campbell Creek Road.

The IC establishes the following objectives:

- Contain/control the spot fire in Division A.
- Hold remainder of the fire east of Campbell Creek Road (Division B).
- Control the fire south of "H" Line Road.

- Hold the fire west of the ridge/road (Point C to I).
- Hold the fire north of a line between Points A, G, and I.

The first alarm resources are assigned as follows: **Engine 1** is assigned to contain the spot fire west of Campbell Creek Road. **"Campbell Creek Air Attack"** is assigned to support the divisions as needed. Division A has the priority. **Crew 1** will be assigned to Division A to support the suppression effort. **Engine 2** is assigned to begin a hose lay anchoring to Campbell Creek Road on the left flank (Division B). **Engine 3** and **Dozer 1** will also be assigned to Division B. **Engine 4** and **Crew 2** will be assigned to Division Z to begin a direct attack on this flank, using a hose lay and hand line. The fire officers on Engines 1, 2, and 3 are designated "Divisions A, B, and Z, respectively" (Figure 11.5). Note: It is proper to identify the first two Divisions as "A" and "Z." This helps in keeping the division designations (A, B, C, X, Y, Z, etc.) in sequence.

Flanking action will begin on both sides of the main fire.

The IC then places the following order for resources:

2 Type 1 or 2 helicopters with water-dropping capabilities
2 Strike Teams of Type 3 engines
3 Type 2 bulldozers
3 Type 2 water tenders
2 Task Forces of Type 1 handcrews (three crews each)

The IC places a large order for resources. Some of the equipment isn't available.

These resources are requested as immediate need (red lights and siren), usually the closest resources, via the quickest route of travel. They are to report to staging, located south of the ICP on Campbell Creek Road. Dispatch advises that it may be tomorrow before any helicopter support is available. The IC also asks that the Forest Service be notified of the fire and requests that a representative be dispatched. If the fire crosses the forest boundary, a unified command will need to be established. The IC also asks that the property owner be notified.

The IC requests that representatives from the Forest Service be dispatched to the fire, and that the landowner be notified.

The IC plans to assign ordered resources as follows:

- A water tender will be assigned to each of the divisions.
- The second bulldozer will be assigned to assist in constructing fireline in Division Z.
- The engine strike teams will be used to support the divisions as needed.

- The Strike Team Leader for the strike team is designated Division Z.
- The first task force of crews will be assigned to Division Z to support their efforts.
- The second task force of crews will be assigned as needed.
- The third bulldozer will be assigned to Division B to develop the "H" Line Road as fireline.

The IC has developed two containment strategies, one assuming that the flanking action is successful and one where this strategy fails and forces have to back off and think a little bigger. The fuel is so heavy that it may be difficult to safely fire the "H" Line Road. The IC feels that if he doesn't receive the air support

The fire is divided into three divisions and the initial-attack resources are assigned.

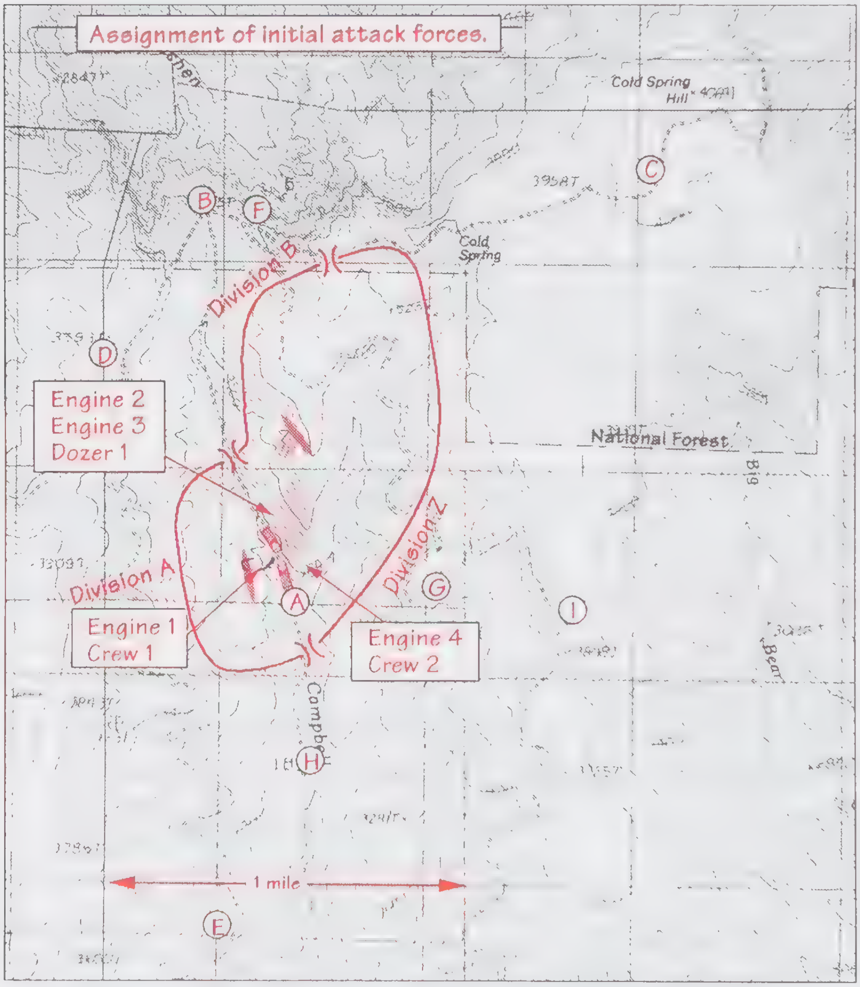
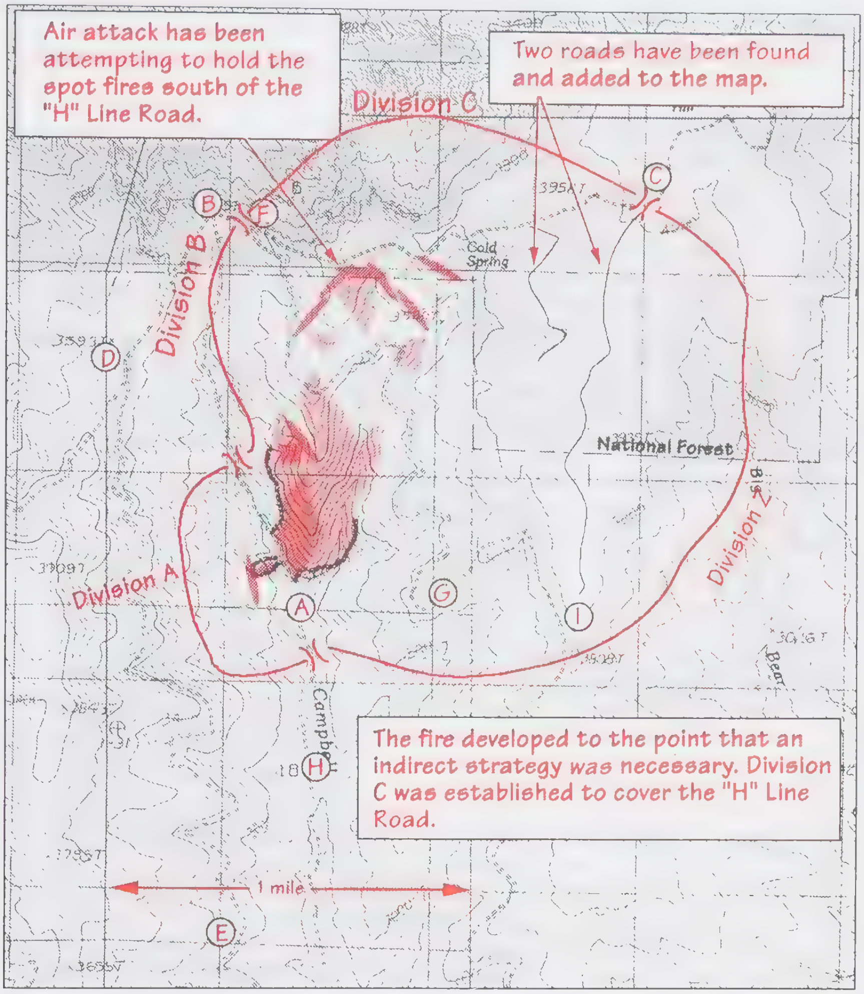

Assignment of initial attack forces.
Cold Spring Hill
Cold Spring
National Forest
Big
Bear
Campbell
Division A
Division B
Division Z
Engine 2
Engine 3
Dozer 1
Engine 1
Crew 1
Engine 4
Crew 2
A
B
C
D
E
F
G
H
I
1 mile

Figure 11.5 The initial-attack forces are deployed on a three-division fire. The spot fire west of Campbell Creek Road is the highest priority. Line construction will begin on each of the flanks. Additional forces will be ordered to support this action.

that has been requested, he will not be able to take the heat out of the fire, and stopping it on the "H" Line Road will be difficult, especially if the wind picks up as predicted (Figure 11.6).

The IC needs the aircraft to take the heat out of the fire.

Division C is established along the "H" Line Road.


Air attack has been attempting to hold the spot fires south of the "H" Line Road.

Two roads have been found and added to the map.

The fire developed to the point that an indirect strategy was necessary. Division C was established to cover the "H" Line Road.

Two roads not on the map are plotted.

Figure 11.6 The fire has spotted well ahead of the main fire. Airtanker drops are being used to contain them. The fire has been divided into four divisions.

Airtankers are used tc contain the spot fires

If the first strategy to flank the fire pinching off the head fails, Division C will be established along the "H" Line Road. Two of the bulldozers will be assigned to Division C to widen it and to open the road between Points C and I. In addition, one of the engine strike teams and one of the handcrew task forces will be assigned to Division C. The Strike Team Leader with the engine strike team is designated "Division C."

The IC discusses his plan with the lead dispatcher. He says that the forces presently assigned to the fire will be used on the

The IC discusses plans with the dispatch office.

night shift. The IC further advises that if the fire is contained by sundown, he will be ordering the following resources for tomorrow's day-shift:

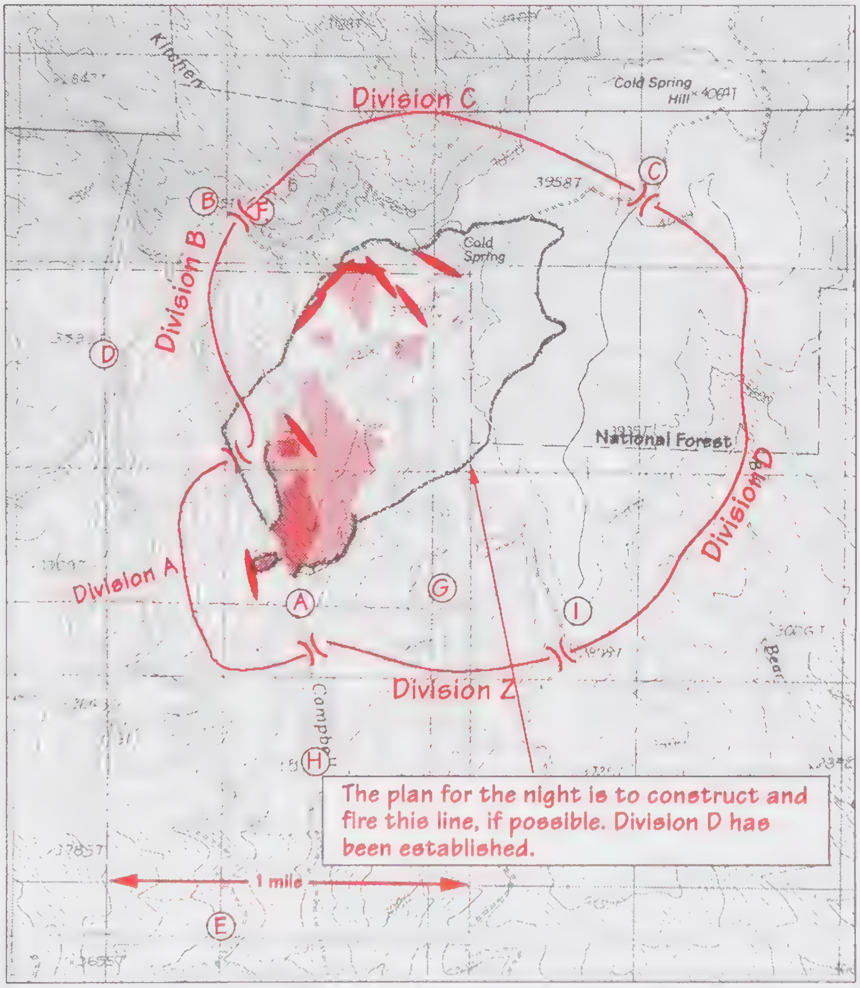
4 Type 2 handcrew task forces
2 Type 3 engine strike teams
2 relief operators for two of the bulldozers
2 relief operators for two water tenders

If the fire is not contained by sundown, a major order for resources will be placed.

If the fire is not contained by sundown, the IC will be placing a major order for resources. His order would be:

1 Major Incident Management Team (with the plan to transition to them by 1800 hours tomorrow).
A minimum of four Type 1 handcrew task forces
4 additional Type 2 bulldozers and relief operators for those already assigned
4 Type 3 engine strike teams
Overhead needed to support a two-branch, six-division incident
Personnel to provide an incident base and logistical support

The Fire: It is doubtful that a direct attack will succeed in keeping the fire from crossing the "H" Line Road. The upper-level winds will continue to carry spot fires well ahead of the fire. The heat will have to be taken out of the fire before it will begin to slow. You may have to think about developing a plan to control the fire in the 300 acre range. Extensive action will be needed to turn the fire to the east so that it can be controlled on the flatter area between Points C and I (Figure 11.7).



The plan for the night is to construct and fire this line, if possible. Division D has been established.

Figure 11.7 The fire will probably need to be taken to 300 acres. The "H" Line Road and the spur road that heads south, just west of Point C, can be used as fireline. The road between Points C to I can be used as a secondary line. You may want to develop a four- to six-division organization.

Firefighting Situation 2

You are the Group Supervisor responsible for the Structure Protection Group assigned to Laumann Ridge. You arrive on scene one hour after the fire starts. En route you see the column of smoke pictured in Figure 11.8.

Situation: The previous winter was cold and dry. It is now early August, and the summer has been quite warm. Today's high temperatures will be in the mid 90s with relative humidities in the teens. The wind is southwest at 11 to 13 miles per hour. The 1-hour fuels are at 2%, the 10-hour fuel sticks are at 2%, and the 1000-hour fuels are below 10%. According to the Incident Commander, the live fuel moisture in the local chaparral fuels is about 80%.

This area has experienced several arson fires over the last two weeks, several of which burned over 500 acres before they were controlled. This new fire was set about 1300 hours, 200 feet from the local highway, behind several houses (Figure 11.9).

You have been briefed by the Incident Commander at the ICP located at Point A. The IC tells you the fire is now crowning and moving upslope toward

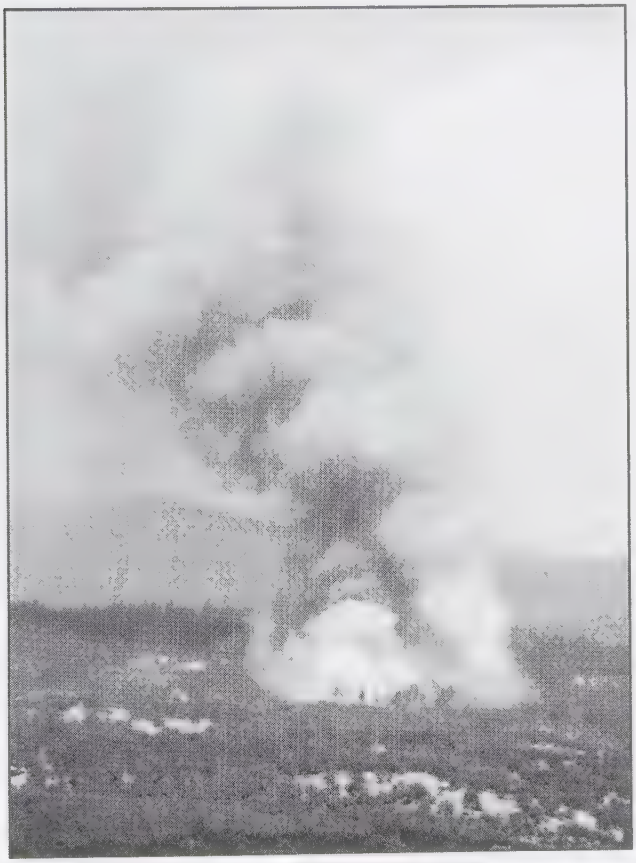


Figure 11.8 This is the column of smoke you see as you approach the fire.

An indirect attack took the fire to 300 acres.

Last winter was dry—a general drought condition exists.

Fuel moistures are critically low.

Laumann Ridge (Points D to H). Several engines are already along the ridge, but they are assigned to Division B (the right flank). You will have two strike teams of engines assigned (one Type 3 strike team from state forestry and one Type 2 strike team from several local fire districts), and one 3,500 gallon water tender. They are presently positioned in Staging at Point C.

The fire was set 200 feet from a road in a populated area.

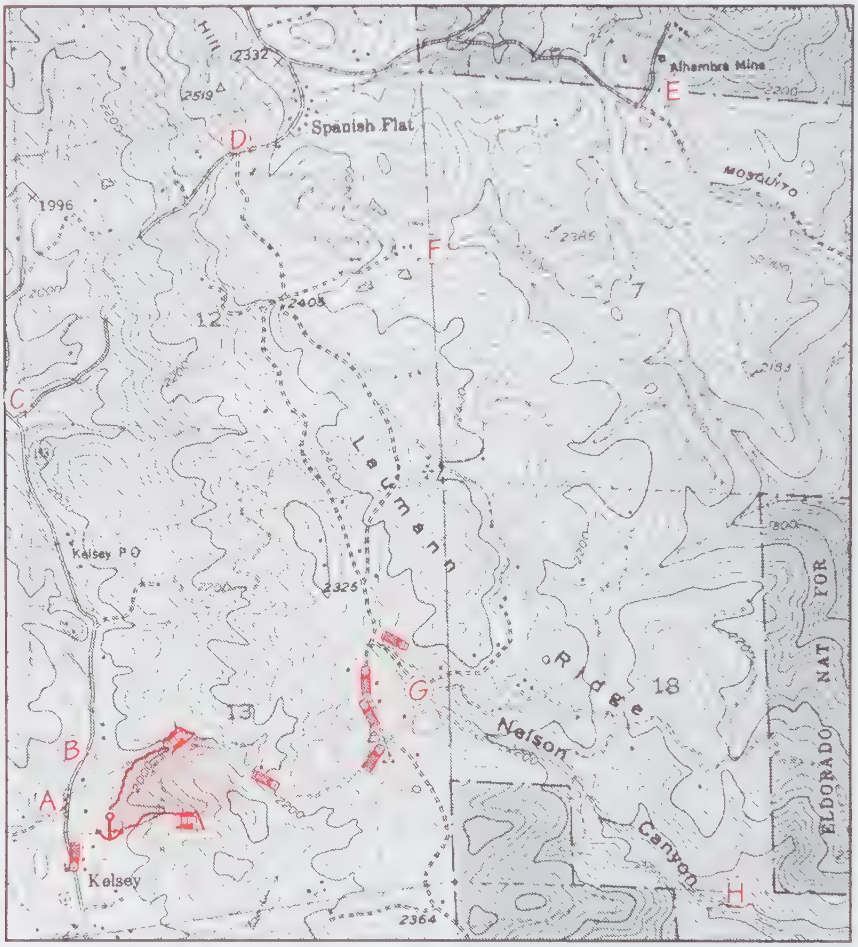

Hill
2332
2519
Spanish Flat
D
Alhambra Mine
E
2200
MOSQUITO
1996
F
2385
2000
12
2405
7
2183
C
Laumann
Ridge
Kelsey P O
2200
2325
2800
G
18
Nelson
Canyon
13
B
A
Kelsey
2364
H
ELDORADO NAT FOR

Figure 11.9 The fire is moving upslope with a southwest wind of about 6 miles per hour. This is on a south-facing slope which is at its peak flammability.

You will be responsible for the protection of structures in front of the fire.

Your resources are in Staging.

The Incident Commander gives you the objectives for the incident and pages from a local road atlas for street name reference (Figure 11.10). The IC assigns you to the protection of structures in front of the fire. You are to coordinate with both Divisions, but to function independently. If your forces can protect structures and also be involved in perimeter control, have them do so; however, such actions should be coordinated with the appropriate Division Supervisor.

You are informed that the overall incident objectives are to:

- Protect the structures on Laumann Ridge.
- Keep the fire from moving into Kelsey and crossing Highway 193 to the west.
- Keep the fire south of Spanish Flat.

You use local street maps for road information.

As you drive up the highway from Point A toward Staging (Point C), you note the primary access road along the left flank, or Division A, of the fire. You also observe a line of mailboxes at Running Springs Lane (Point B) (Figure 11.11). As you continue up the road from Point B toward Point G, you come upon the bulldozer line and Engine 72, which is working this section of line. You take note of the fire behavior; the fire is beginning to run with 8- to 12-foot flame lengths (Figure 11.12). You now proceed to Staging (Point C) and prepare to brief the strike teams on the assignment.

The incident objectives are quite simple and straightforward.

Solution Required: You are in Staging with the two Strike Team Leaders and most of the engine company officers. You are about to brief them on the fire and what you expect of them. What will you tell the group? Be sure to discuss the expected fire behavior, safety, objectives, and tactics. Specifically you are to:

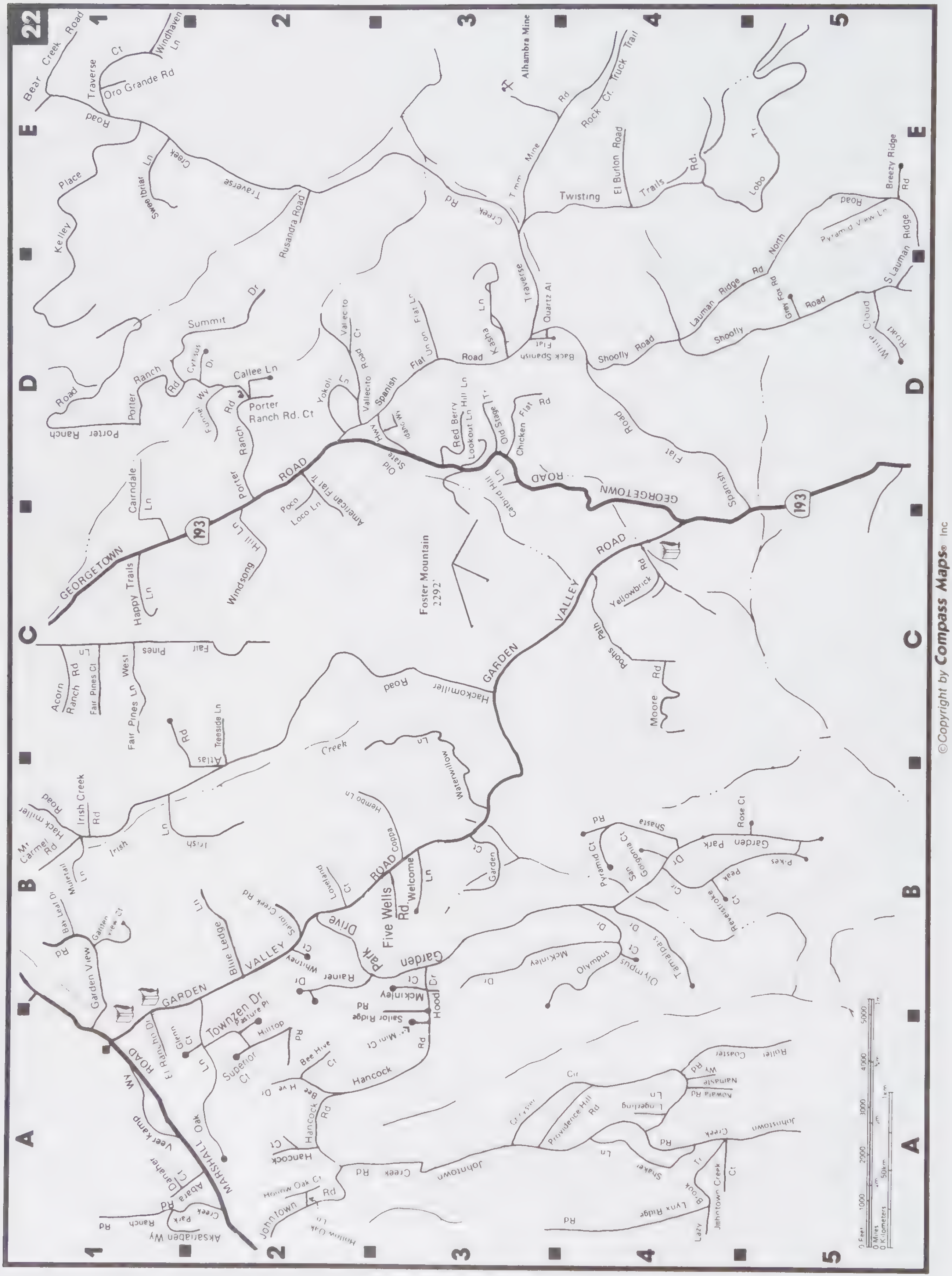
- Deploy the resources assigned to you to specific areas or roads.
- Develop general "rules of engagement" for your forces (what they should do under different conditions) and briefly explain your rationale for various actions.

Possible Solutions: Two different briefings, deployment plans, and the associated rationales will be presented. This situation is based on an actual fire. A summary of this fire is given on page 513.

What will you say to your people?

Briefing 1

The Group Supervisor briefs the Strike Team Leaders on their mission. He starts with a discussion of the expected fire behavior.


22
1
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3
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5
E
D
C
B
A
Bear Creek Road
Traverse Ct
Windhaven Ln
Oro Grande Rd
Road
Place
Kelley
Sweetbriar Ln
Creek
Traverse
Rusandra Road
Alhambra Mine
Rd
Rock Cr. Truck Trail
Mine
El Burton Road
Twisting
Trails
Rd.
Lobo
Creek
Rd
Breezy Ridge Rd
Road
Pyramid View Ln
North
Lauman Ridge Rd
Grey Fox Rd
Road
S Lauman Ridge
White Cloud Road
Shoofly
Shoofly Road
Back Spanish Flat
Quartz Al
Traverse
Kasha Ln
Road
Union Flat Ln
Flat
Spanish
Vallecito Road Ct
Vallecito
Yokoli Ln
Hwy
Summit Dr
Road
Porter Ranch Rd
Cytisus Dr
Callee Ln
Porter Ranch Rd. Ct
Fennel Wy
Rd
Ranch
Porter
Porter Ranch
Red Berry Hill Ln
Lookout Ln
Old Stage Tr
Chicken Flat Rd
Old State Hwy
Road
Flat
Spanish
ROAD
GEORGETOWN
Cabrillo Hill Ln
193
Poco Loco Ln
American Flat Tr
Carrndale Ln
GEORGETOWN ROAD
Happy Trails Ln
Hill Ln
Windsong
Foster Mountain 2292'
ROAD
VALLEY
GARDEN
Yellowbrick Rd
Poons Path
Moore Rd
Fair Pines
West
Acorn Ranch Rd
Fair Pines Ct
Fair Pines Ln
Hackomiller Road
Treeside Ln
Rd
Atlas
Creek
Waterwillow Ln
Hembo Ln
Irish Creek Rd
Hack miller Road
Mt Carmel Rd
Irish
Ln
Irish
Muletail Ln
Coppa
ROAD
Loveland Ct
Welcome Ln
Five Wells Rd.
Garden Ct
Shasta Rd
Rose Ct
Pyramid Ct
San Gorgonia Ct
Garden Park Dr
Pikes Peak Ct
Cir
Reventstoke Ct
Bay Leaf Dr
Garden View Ct
Garden View Rd
Blue Ledge Ln
Sailor Creek Rd
Park Drive
Garden
VALLEY
Whitney Ct
Rainer Dr
GARDEN
McKinley Dr
Olympus
Olympus Ct
Tamalpais Dr
Mckinley Ct
Hood Dr
Sailor Ridge Rd
Lt. Mtn Ct
Rd
Townzen Dr
Pasture Pl
Hilltop Rd
El Rancho Dr
Glenn Ct
Superior Ct
Bee Hive Ct
Bee Hive Dr
Hancock
Hancock Rd
Hancock Ct
Oak Ln
ROAD
Wy
Veerkamp
MARSHALL
Gallaher Ct
Abara Dr
Rd
Creek Park Ranch Rd
Aksarben Wy
Johntown Rd
Hollow Oak Ct
Hollow Oak Ln
Creek Rd
Johntown
Cir
Providence Hill Rd
Crossier
Ln
Shaker
Lingering Ln
Rowena Rd
Nahdale
Wy Rd
Roller Coaster
Johntown Creek Rd
Tr
Brook
Johntown Creek Ct
Lazy
Lynx Ridge Rd
0 Feet 1000 2000 3000 4000 5000
0 Miles
0 Kilometers
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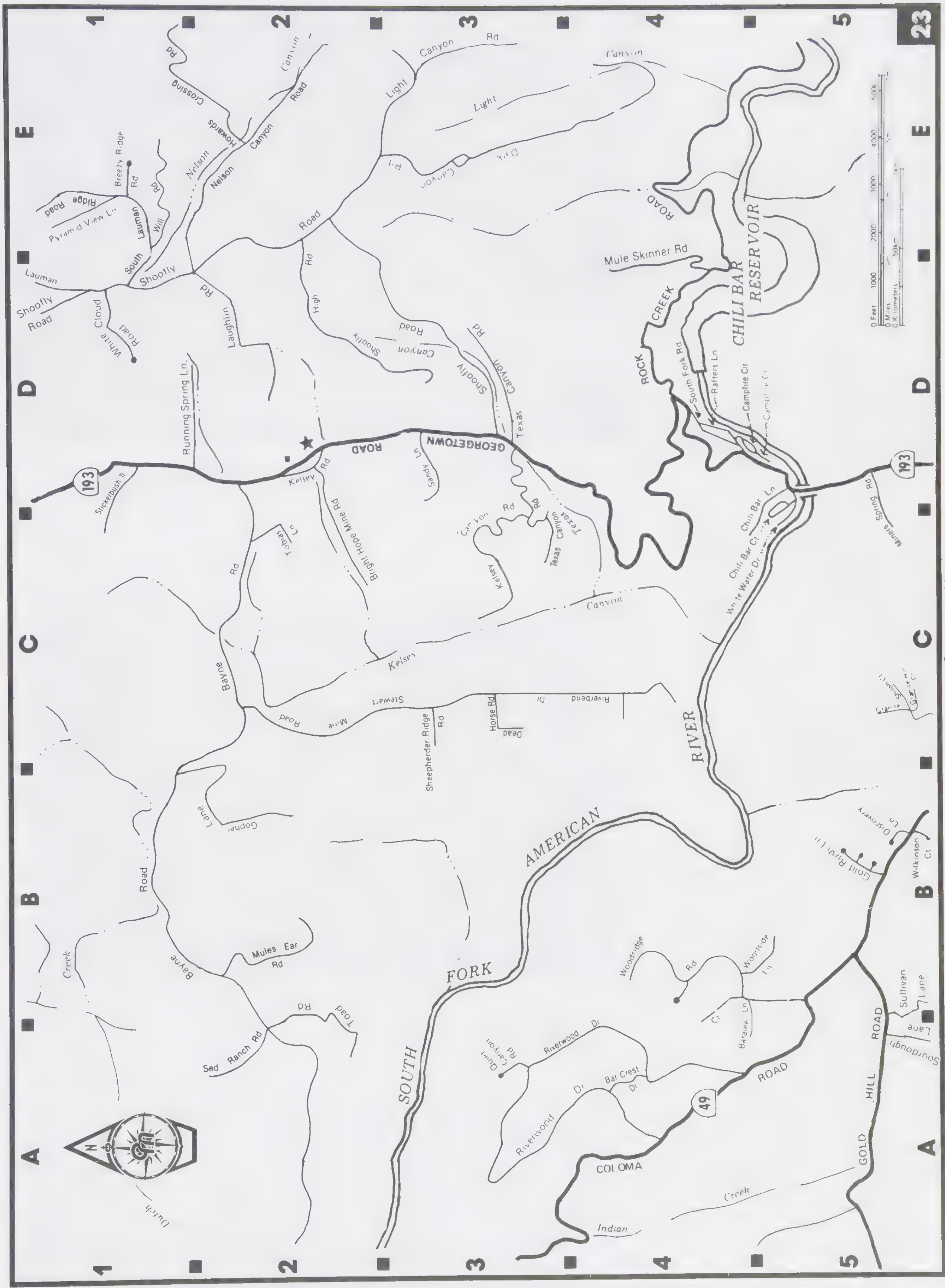
23
GEORGETOWN ROAD
193
49
CHILI BAR RESERVOIR
ROCK CREEK ROAD
SOUTH FORK AMERICAN RIVER
Mule Skinner Rd
South Fork Rd
Ratters Ln
Campfire Cir
Campfire Ct
Chili Bar Ln
Chili Bar Ct
White Water Dr
Mines Spring Rd
Kelsey Canyon
Stewart Mine Road
Riverbend Dr
Horse Rd
Dead
Sheepherder Ridge Rd
Bayne Road
Gopher Lane
Mules Ear Rd
Sed Ranch Rd
Toad Rd
Dutch Creek
Creek
Indian Creek
COLOMA ROAD
GOLD HILL ROAD
Riverwood Dr
Bar Crest Dr
Quiet Canyon Rd
Woodridge Rd
Woodside Ln
Baraiee Ln
Ct
Sullivan Lane
Sourdough Lane
Gold Rush Ln
Discovery Ln
Wilkinson Ct
Granite
Kelsey Rd
Tobias Ln
Bright Hope Mine Rd
Sandy Ln
Texas Canyon Rd
Canyon Rd
Stickerbush Tr
Running Spring Ln
Laughlin Rd
High Rd
Shoofly Canyon Road
Shoofly Road
White Cloud Road
Lauman
South Lauman
Will Rd
Pyramid View Ln
Ridge Road
Breezy Ridge Rd
Nelson
Howards Crossing Rd
Nelson Canyon Road
Light Canyon Rd
Dark Canyon Rd
Canyon
Light
ROAD
A B C D E
1 2 3 4 5
0 Feet 1000 2000 3000 4000 5000
0 Miles
0 Kilometers

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Figure 11.10 Two pages from a local street atlas that can be used to identify roads.

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Count the mail boxes. It will give you some idea of how many structures there are.

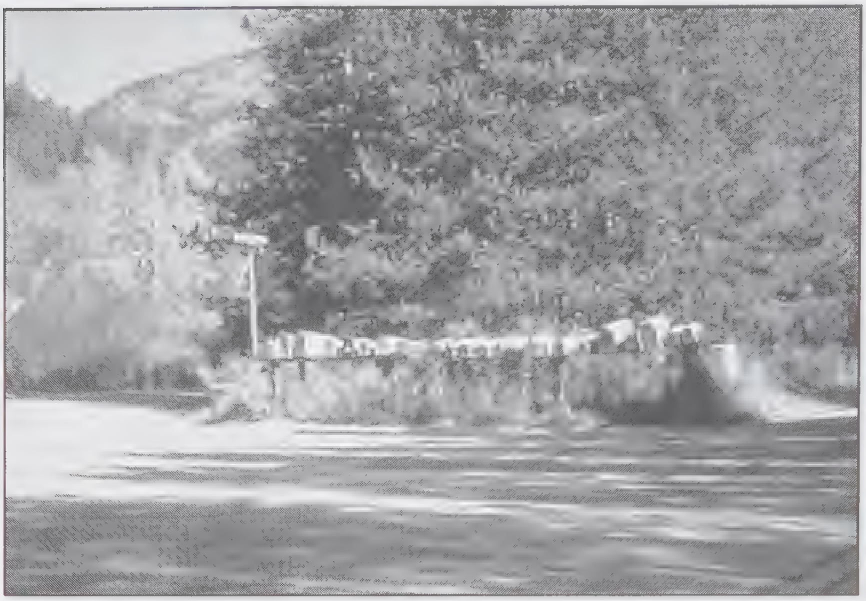


Figure 11.11 You take note of this line of mailboxes at the intersection of the main highway and the primary access to the left flank of the fire.

The flame length indicates there is a potential for extreme fire behavior.

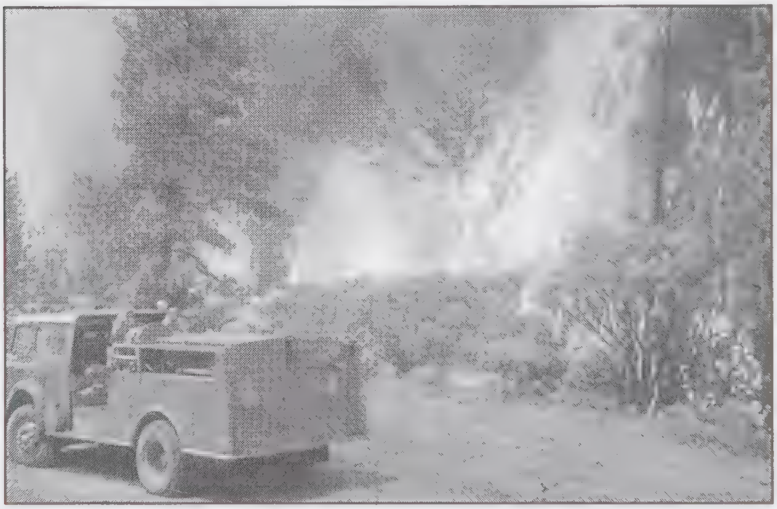


Figure 11.12 Engine 72 is working behind a bulldozer on Division A, the left flank.

Assignment - The two strike teams and the water tender are assigned to protect the structures ahead of the fire along Laumann Ridge. The Supervisor uses the maps provided by the IC to brief the group.

Fire Behavior - Based on a fire behavior analysis determined by using a nomogram, the expected flame length will be between

2 to 8 feet in length, with a rate-of-spread of well over one mile per hour. The slope, wind, and aspect will probably support the same spread rate for several hours. The Supervisor tells the group he will be taking regular weather readings and will advise them of any changes.

The Group Supervisor briefs all of his personnel.

Safety Concerns - Use the standard procedures when protecting structures. Watch fuel loading and canopy along the roads. Back into driveways. Identify potential safety zones and escape routes. Each Strike Team Leader is told to identify safety zones, the routes that will be used, and what event will trigger a move for their own forces.

Rules of Engagement - Base your protection on fireline intensity, flame lengths, and what you are trying to protect. In addition, you need to consider the resources available and your water supply.

Specific assignments are given.

Deployment - The Supervisor deploys his resources along Shoofly Road and Shoofly High Road on the south side of the fire. He also deploys engines on White Cloud Road, Lauman Ridge, South Lauman Ridge Road, Pyramid View Lane, and Brezzy Ridge Road.

Briefing 2

Don't attempt to save "losers."

The Group Supervisor introduces herself to the group, providing a brief background of her assignment and experience.

Situation Report - The fire is out of control and will be rapidly moving upslope towards our location and into homes around and above us. We are to provide structure protection **to the best of our ability,** as the fire appears to be unstoppable prior to getting to the structures.

Safety is the primary concern for us and the public who might be in the area. Fire Officers are to consider the safety implications prior to any actions.

Protect structures as best you can.

The Supervisor points out that they cannot cover all the structures that will be threatened when the fire reaches their position and moves beyond. They will pick those structures that have adequate clearance, safe ingress/egress, and that have a water source. Engine companies should make quick decisions on which structures have the highest probability of being saved. The

Fire Officers should be advised that they can limit their efforts to only those structures they feel they can save.

Fire Officers should know where all their people are at all times. If they are away from the engine, two long blasts of the engine's horn will be the signal to return to the unit **without hesitation, as it is time to move out!**

Safety of the public and of the firefighters is a primary concern.

Strike Team Leaders should position themselves in the most strategic locations to communicate with their engine companies and the Group Supervisor.

Two blasts on the horn means we're moving out NOW!

Rules of Engagement - The Group Supervisor outlines the rules of engagement that they will use:

- All apparatus will have their lights on at all times, as visibility is going to worsen. Plus, local citizen traffic may become heavy and panicky.
- Within 20 minutes, both strike teams must complete their initial triage of structures within their assigned areas.
- Determine which structures are "winners" as quickly as possible, and determine which ones cannot be safely and successfully defended.
- Once determination has been made that a safe and successful effort can be expended upon a certain structure, back the apparatus in to allow a quick get away, if necessary.
- Establish a water source at your working area.
- All units are to constantly monitor the assigned tactical net.
- Understand that the escape route for apparatus is to Shoofly Road and north. Should it be necessary to pull out, Strike Team Leaders are responsible for verifying that all units under their direction understand this directive.

The Group Supervisor outlines extensive rules of engagement.

As Fire Officers feel it is safe to leave a "saved" structure, they can move to the next "winner." Notify the Strike Team Leader of your new location.

Deployment - One strike team will move to Laughlin Road and north along Shoofly Road to triage the structures. The second strike team is to move to Shoofly Road (south of Laughlin Road) and to Dark Canyon Road. They are also assigned to cover Shoofly High Road.

The Group Supervisor specifies the escape routes to be used.

The Group Supervisor now tells the Strike Team Leaders to perform a final check of their personnel and apparatus and to proceed to their assigned areas. He will be updating the IC on his actions and plans. He will be requesting several additional strike teams of the closest Type 2 or 3 engines. They are to respond "code 3" to a new staging area at the intersection of Spanish Flat Road and Shoofly Road (Point D).

Once a structure is safe, the engine company is to move on and attempt to save another.

Kelsey Fire

The previous fire situation was based on an actual fire that occurred in the foothills of Central California on August 7, 1994, under the jurisdiction of the California Department of Forestry and Fire Protection (wildland protection) and the Garden Valley Fire Protection District (structure protection). The fire burned with considerable speed until about 1900 hours, when the humidity increased (Figure 11.13).

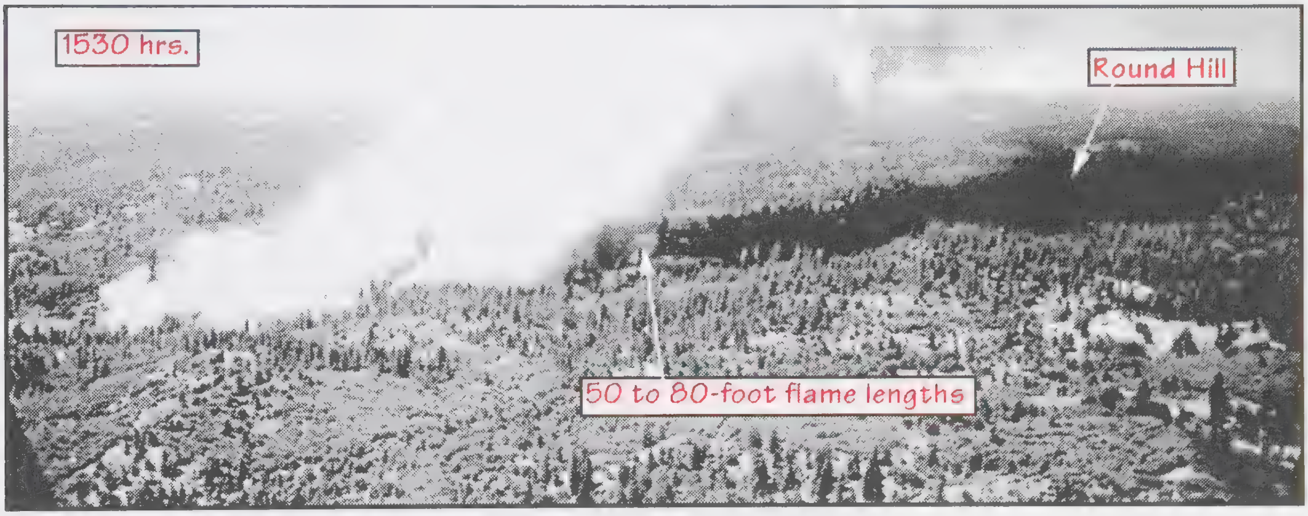


Figure 11.13 This photograph was taken by the air attack at about 1530 hours.

At about 1430 hours, several engine companies were laying a progressive hose lay on Division A (left flank) just south of the center of Section 13 (between Points B and G). They were attacking a backing fire in light ground fuels. The fire spotted below them and cut off their ability to retreat back along their hose lay. They escaped by running uphill through the black. They escaped with burns from the radiated heat, but were released from the hospital late that evening.

Make a final safety check of your people and equipment before you move out of staging.

The Kelsey Fire burned 860 acres (Figure 11.14), destroying 5 homes and 12 other structures before it was controlled. The fire crossed Shoofly Road about 1540 hours and Laumann Ridge between 1615 to 1630 hours. By the morning of August 8, the firefighting resources assigned to the incident were:

95 engine companies
24 bulldozers
16 water tenders
36 handcrews
6 airtankers
6 helicopters
113 overhead and logistical support personnel

The Kelsey Fire burned 860 acres, destroying 5 homes and 12 other structures.

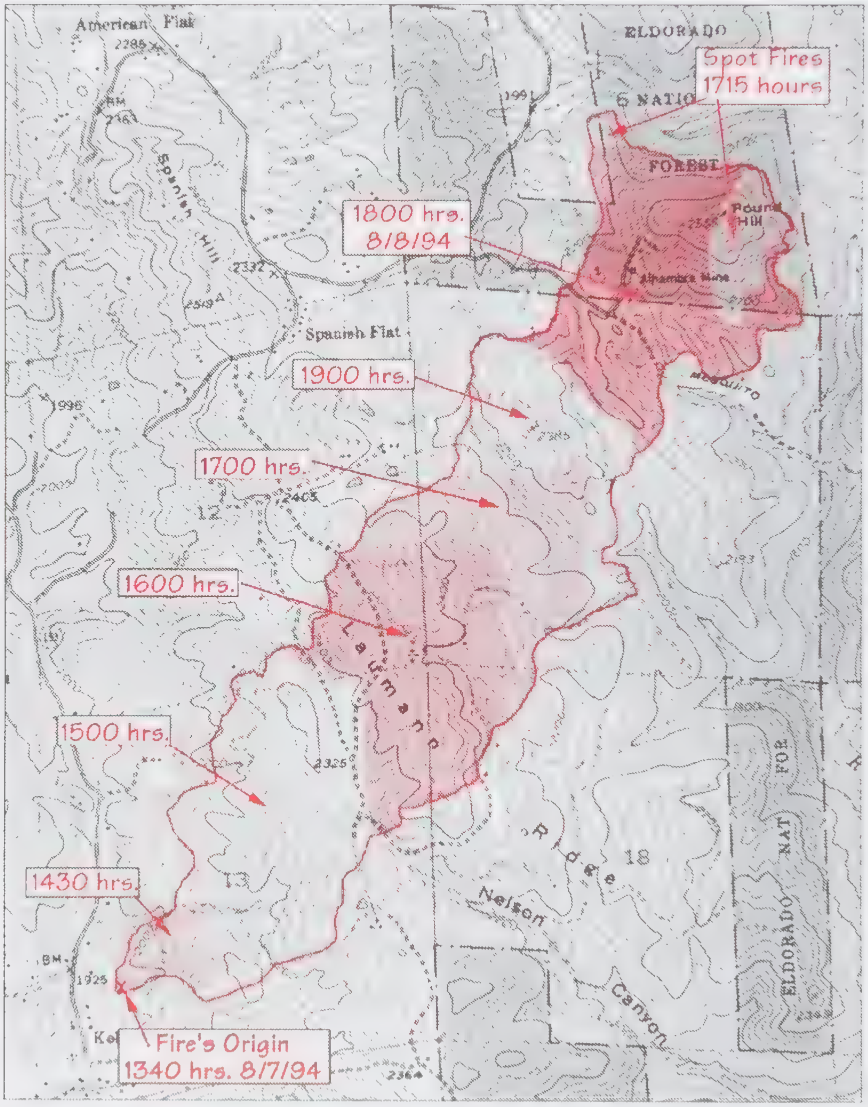

American Flat
2285
ELDORADO
Spot Fires
1715 hours
NATIO
FOREST
Round Hill
Alhambra Mine
1800 hrs.
8/8/94
Spanish Hill
2332
Spanish Flat
1900 hrs.
1996
1700 hrs.
2405
12
1600 hrs.
Laumann
2193
1500 hrs.
2325
Ridge
18
Nelson
Canyon
1430 hrs.
13
BM
1925
ELDORADO NAT FOR
Fire's Origin
1340 hrs. 8/7/94
2364

Figure 11.14 The fire burned in heavy fuels, spotting about a mile at 1715 hours.

Firefighting Situation 3

You are a Division/Group Supervisor on a fire in the Northern Rockies. The fire started on July 26 and has been burning for several days in heavy timber and slash. You are assigned to the fire on July 29. The fire is just over 5,000 acres in size.

The weather has been hot and dry. The fire made a major run on July 28, burning over 3,500 acres in just a couple of hours. Yesterday's high temperature was 98°, the wind was generally 14 miles per hour from the southwest; the relative humidity in the afternoon was 18%. As you drive into the area, you see the smoke column pictured in Figure 11.15.

The fire is over 3,000 acres, and you are assigned as a Division/ Group Supervisor.

Situation: Within minutes of arriving at the Incident Base, you are briefed by the Planning Section Chief. She provides you with a two-page Assignment List for Division C (Figures 11.16 and 11.17), a copy of the latest weather forecast (Figure 11.18), and a copy of the latest map (Figure 11.19).

The fire is burning with extreme fire behavior. Note the "white cap" on the top of the smoke column.

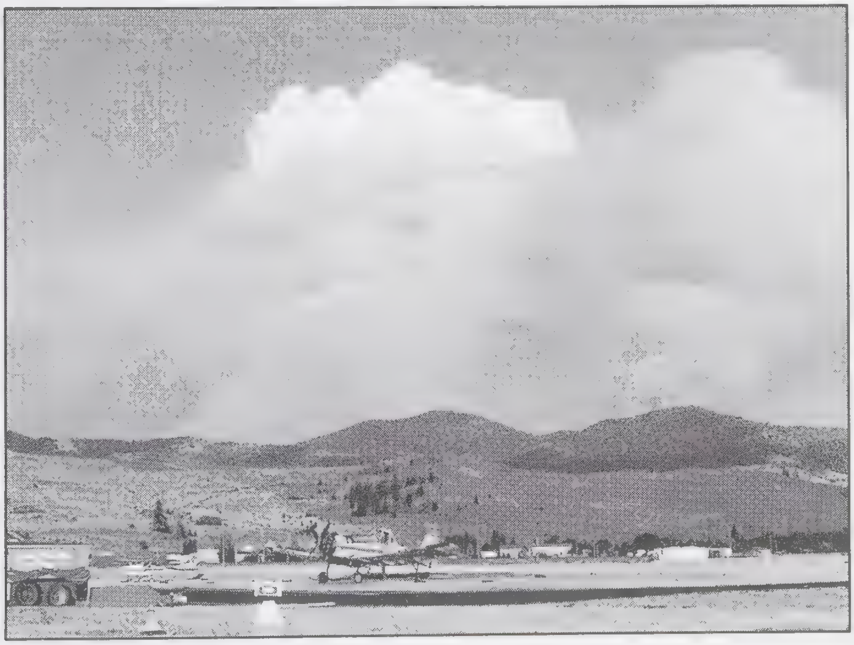
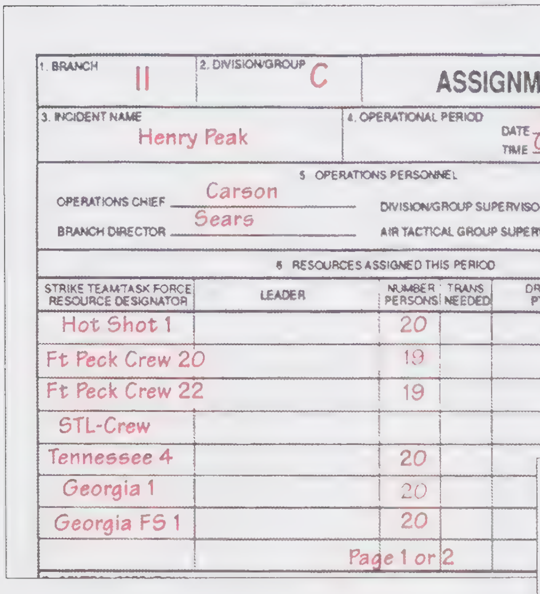


Figure 11.15 This is what the smoke column looks like as you drive into the area.

You are given your assignment by the Planning Section Chief.



1. BRANCH II
2. DIVISION/GROUP C

ASSIGNMENT LIST

3. INCIDENT NAME Henry Peak
4. OPERATIONAL PERIOD DATE 7/29 TIME 0630-1900

5. OPERATIONS PERSONNEL

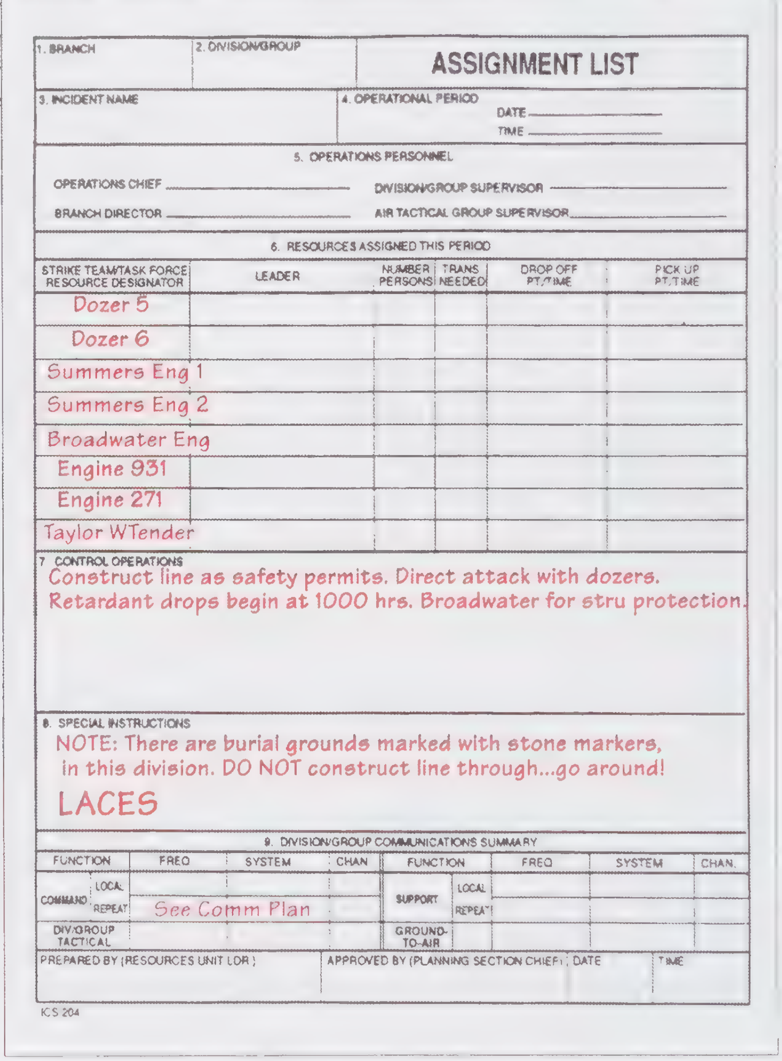
OPERATIONS CHIEF Carson
DIVISION/GROUP SUPERVISOR You
BRANCH DIRECTOR Sears
AIR TACTICAL GROUP SUPERVISOR

6. RESOURCES ASSIGNED THIS PERIOD

STRIKE TEAM/TASK FORCE RESOURCE DESIGNATOR	LEADER	NUMBER PERSONS	TRANS NEEDED	DROP OFF PT/TIME	PICK UP PT/TIME
Hot Shot 1		20			
Ft Peck Crew 20		19			
Ft Peck Crew 22		19			
STL-Crew					
Tennessee 4		20			
Georgia 1		20			
Georgia FS 1		20			
	Page 1 or	2			

Figure 11.16 Page 1 of 2, of the Assignment List for Division C, July 29, day shift.

You will be assigned to Division C. There are structures that must be protected.



1. BRANCH
2. DIVISION/GROUP

ASSIGNMENT LIST

3. INCIDENT NAME
4. OPERATIONAL PERIOD DATE TIME

5. OPERATIONS PERSONNEL

OPERATIONS CHIEF
DIVISION/GROUP SUPERVISOR
BRANCH DIRECTOR
AIR TACTICAL GROUP SUPERVISOR

6. RESOURCES ASSIGNED THIS PERIOD

STRIKE TEAM/TASK FORCE RESOURCE DESIGNATOR	LEADER	NUMBER PERSONS	TRANS NEEDED	DROP OFF PT/TIME	PICK UP PT/TIME
Dozer 5					
Dozer 6					
Summers Eng 1					
Summers Eng 2					
Broadwater Eng					
Engine 931					
Engine 271					
Taylor WTender					

7. CONTROL OPERATIONS

Construct line as safety permits. Direct attack with dozers.
Retardant drops begin at 1000 hrs. Broadwater for stru protection.

8. SPECIAL INSTRUCTIONS

NOTE: There are burial grounds marked with stone markers,
in this division. DO NOT construct line through...go around!

LACES

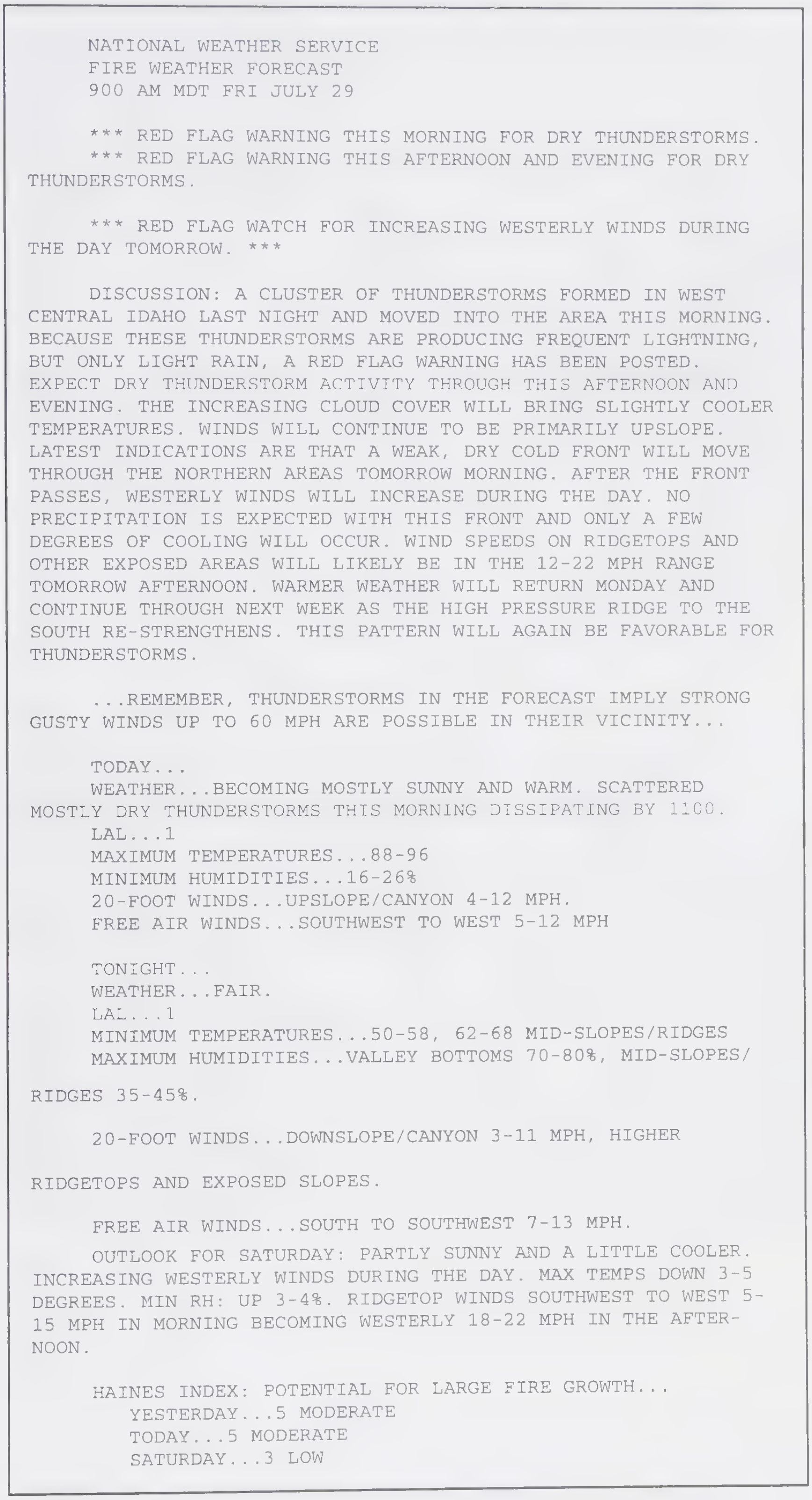
9. DIVISION/GROUP COMMUNICATIONS SUMMARY

FUNCTION		FREQ	SYSTEM	CHAN	FUNCTION		FREQ	SYSTEM	CHAN.
COMMAND	LOCAL				SUPPORT	LOCAL			
	REPEAT	See Comm Plan				REPEAT			
DIV/GROUP TACTICAL					GROUND-TO-AIR				

PREPARED BY (RESOURCES UNIT LDR.)
APPROVED BY (PLANNING SECTION CHIEF)
DATE
TIME

ICS 204

Figure 11.17 Page 2 of 2, of the Assignment List for Division C, July 29, day shift.



```
     NATIONAL WEATHER SERVICE
     FIRE WEATHER FORECAST
     900 AM MDT FRI JULY 29

     *** RED FLAG WARNING THIS MORNING FOR DRY THUNDERSTORMS.
     *** RED FLAG WARNING THIS AFTERNOON AND EVENING FOR DRY
THUNDERSTORMS.

     *** RED FLAG WATCH FOR INCREASING WESTERLY WINDS DURING
THE DAY TOMORROW. ***

     DISCUSSION: A CLUSTER OF THUNDERSTORMS FORMED IN WEST
CENTRAL IDAHO LAST NIGHT AND MOVED INTO THE AREA THIS MORNING.
BECAUSE THESE THUNDERSTORMS ARE PRODUCING FREQUENT LIGHTNING,
BUT ONLY LIGHT RAIN, A RED FLAG WARNING HAS BEEN POSTED.
EXPECT DRY THUNDERSTORM ACTIVITY THROUGH THIS AFTERNOON AND
EVENING. THE INCREASING CLOUD COVER WILL BRING SLIGHTLY COOLER
TEMPERATURES. WINDS WILL CONTINUE TO BE PRIMARILY UPSLOPE.
LATEST INDICATIONS ARE THAT A WEAK, DRY COLD FRONT WILL MOVE
THROUGH THE NORTHERN AREAS TOMORROW MORNING. AFTER THE FRONT
PASSES, WESTERLY WINDS WILL INCREASE DURING THE DAY. NO
PRECIPITATION IS EXPECTED WITH THIS FRONT AND ONLY A FEW
DEGREES OF COOLING WILL OCCUR. WIND SPEEDS ON RIDGETOPS AND
OTHER EXPOSED AREAS WILL LIKELY BE IN THE 12-22 MPH RANGE
TOMORROW AFTERNOON. WARMER WEATHER WILL RETURN MONDAY AND
CONTINUE THROUGH NEXT WEEK AS THE HIGH PRESSURE RIDGE TO THE
SOUTH RE-STRENGTHENS. THIS PATTERN WILL AGAIN BE FAVORABLE FOR
THUNDERSTORMS.

     ...REMEMBER, THUNDERSTORMS IN THE FORECAST IMPLY STRONG
GUSTY WINDS UP TO 60 MPH ARE POSSIBLE IN THEIR VICINITY...

     TODAY...
     WEATHER...BECOMING MOSTLY SUNNY AND WARM. SCATTERED
MOSTLY DRY THUNDERSTORMS THIS MORNING DISSIPATING BY 1100.
     LAL...1
     MAXIMUM TEMPERATURES...88-96
     MINIMUM HUMIDITIES...16-26%
     20-FOOT WINDS...UPSLOPE/CANYON 4-12 MPH.
     FREE AIR WINDS...SOUTHWEST TO WEST 5-12 MPH

     TONIGHT...
     WEATHER...FAIR.
     LAL...1
     MINIMUM TEMPERATURES...50-58, 62-68 MID-SLOPES/RIDGES
     MAXIMUM HUMIDITIES...VALLEY BOTTOMS 70-80%, MID-SLOPES/

RIDGES 35-45%.

     20-FOOT WINDS...DOWNSLOPE/CANYON 3-11 MPH, HIGHER

RIDGETOPS AND EXPOSED SLOPES.

     FREE AIR WINDS...SOUTH TO SOUTHWEST 7-13 MPH.
     OUTLOOK FOR SATURDAY: PARTLY SUNNY AND A LITTLE COOLER.
INCREASING WESTERLY WINDS DURING THE DAY. MAX TEMPS DOWN 3-5
DEGREES. MIN RH: UP 3-4%. RIDGETOP WINDS SOUTHWEST TO WEST 5-
15 MPH IN MORNING BECOMING WESTERLY 18-22 MPH IN THE AFTER-
NOON.

     HAINES INDEX: POTENTIAL FOR LARGE FIRE GROWTH...
        YESTERDAY...5 MODERATE
        TODAY...5 MODERATE
        SATURDAY...3 LOW
```

Figure 11.18 Fire Weather Forecast for July 29 for the local area.

Red flag warnings are issued for dry thunderstorms.

Temperatures will be in the 90s. Relative humidity will be in the teens.

Winds will be between 5 to 12 mph.

There are structures all along the south flank of Division C.

The fire is generally burning east and south.

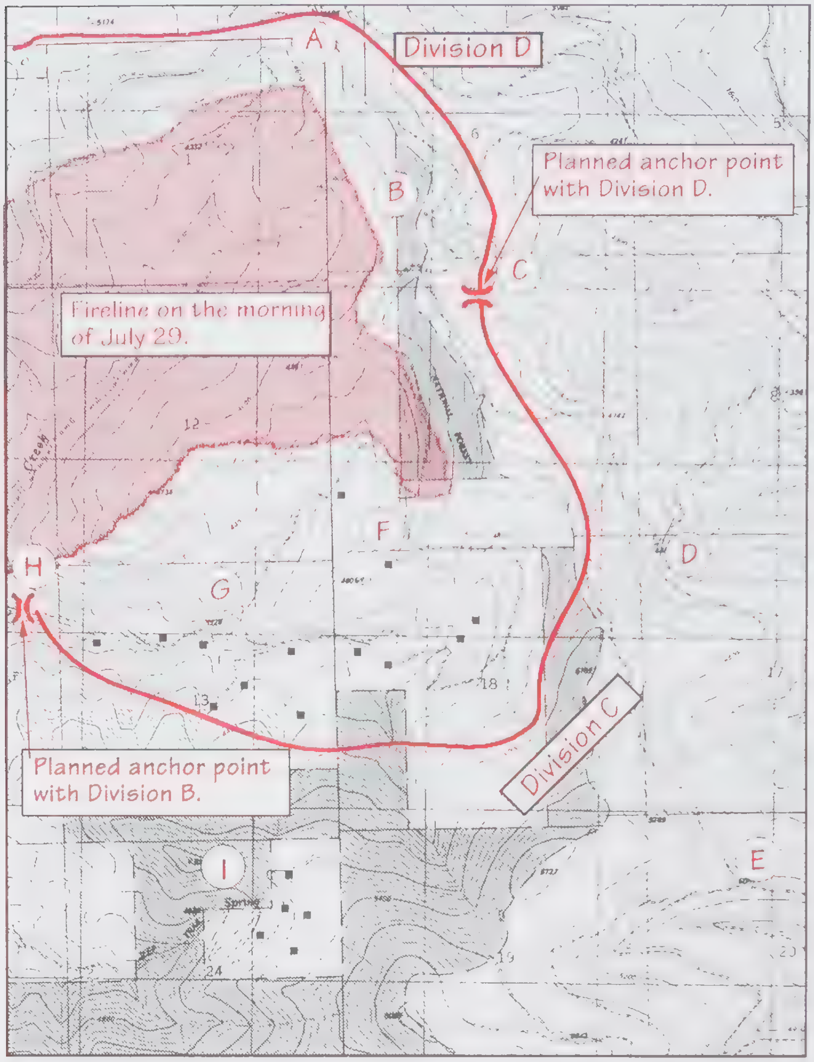

A
Division D
B
Planned anchor point with Division D.
C
Fireline on the morning of July 29.
12
F
D
H
G
13
18
Division C
Planned anchor point with Division B.
E
I
Spring
24
19
20

Figure 11.19 Contour map of Division C.

You are concerned about the weather.

You discuss your concerns over the weather forecast and the large number of resources assigned to the division (the number exceeds the normal span of control) with the Planning Section Chief. She says that additional overhead is not available.

You then proceed to the division. As you move up the access road you note the smoke column and fuel types (Figure 11.20). You also note one of the many summer cabins threatened by the fire (Figure 11.21).

As you arrive on the fireline, you meet with the fire behavior specialist. He is in the field, double-checking his predictions. He gives you his prediction for the next 24 hours (Figure 11.22). He estimates that the fire will travel about a mile, on this shift, under

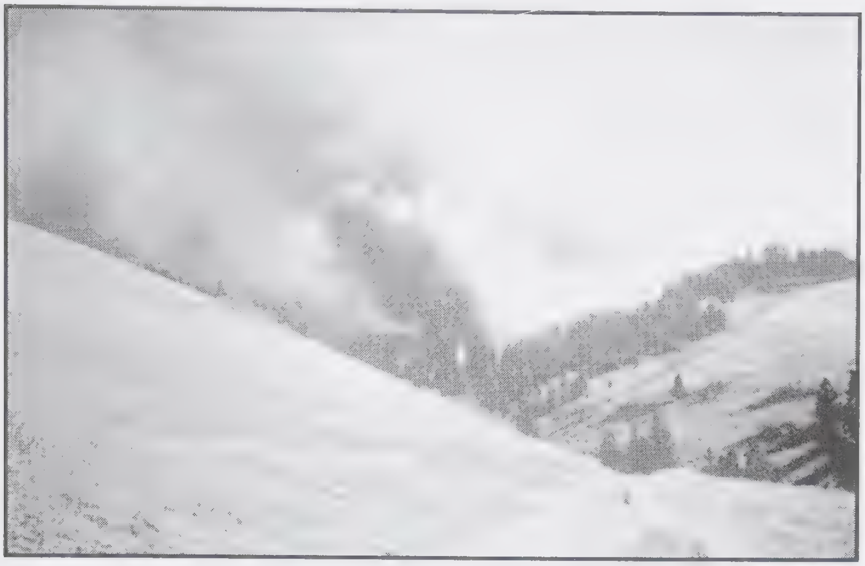


Figure 11.20 You are heading up the fireline in a westerly direction and note that the fire is being pushed by a south-to-southwest wind.

There is some open terrain that may aid in the suppression efforts.

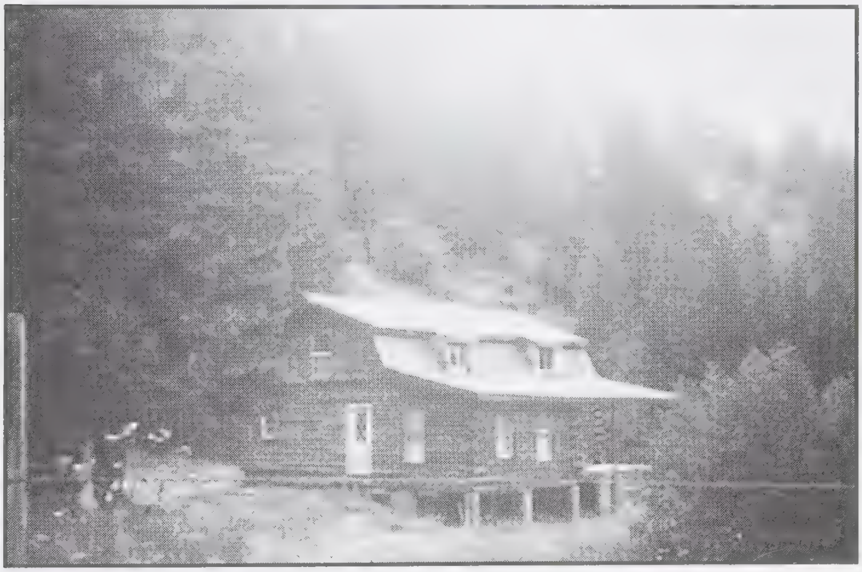
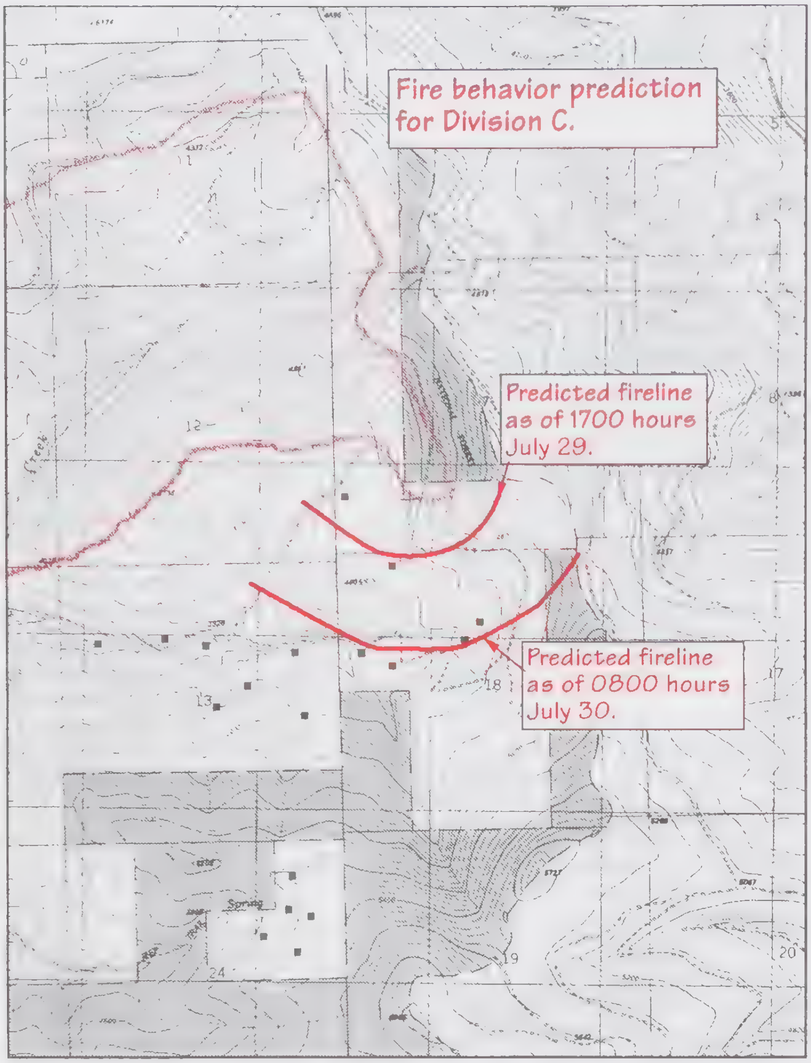


Figure 11.21 This is one of the many cabins along the access road to Division C. This cabin will be threatened by the fire this afternoon.

Most of the structures do not have adequate clearance.

Be sure you know where your division begins and ends.

the present conditions. You meet with Division B and discuss the anchor point between the two divisions (Point H). You will contact Division D face to face or by radio later.



Fire behavior prediction for Division C.

Predicted fireline as of 1700 hours July 29.

Predicted fireline as of 0800 hours July 30.

Figure 11.22 The fire behavior prediction for the next 24 hours.

Solution Required: You are to develop a plan to deploy the resources assigned to the division. Your plan should address your concerns regarding the weather forecast, the safety of the firefighters, and protection of the numerous structures that will be threatened.

Specifically, you are to:

- Deploy the resources and outline the tactics to be used.
- Develop a plan to protect the structures on your division.
- Develop a plan in the event the thunderstorms materialize and pass through the area.

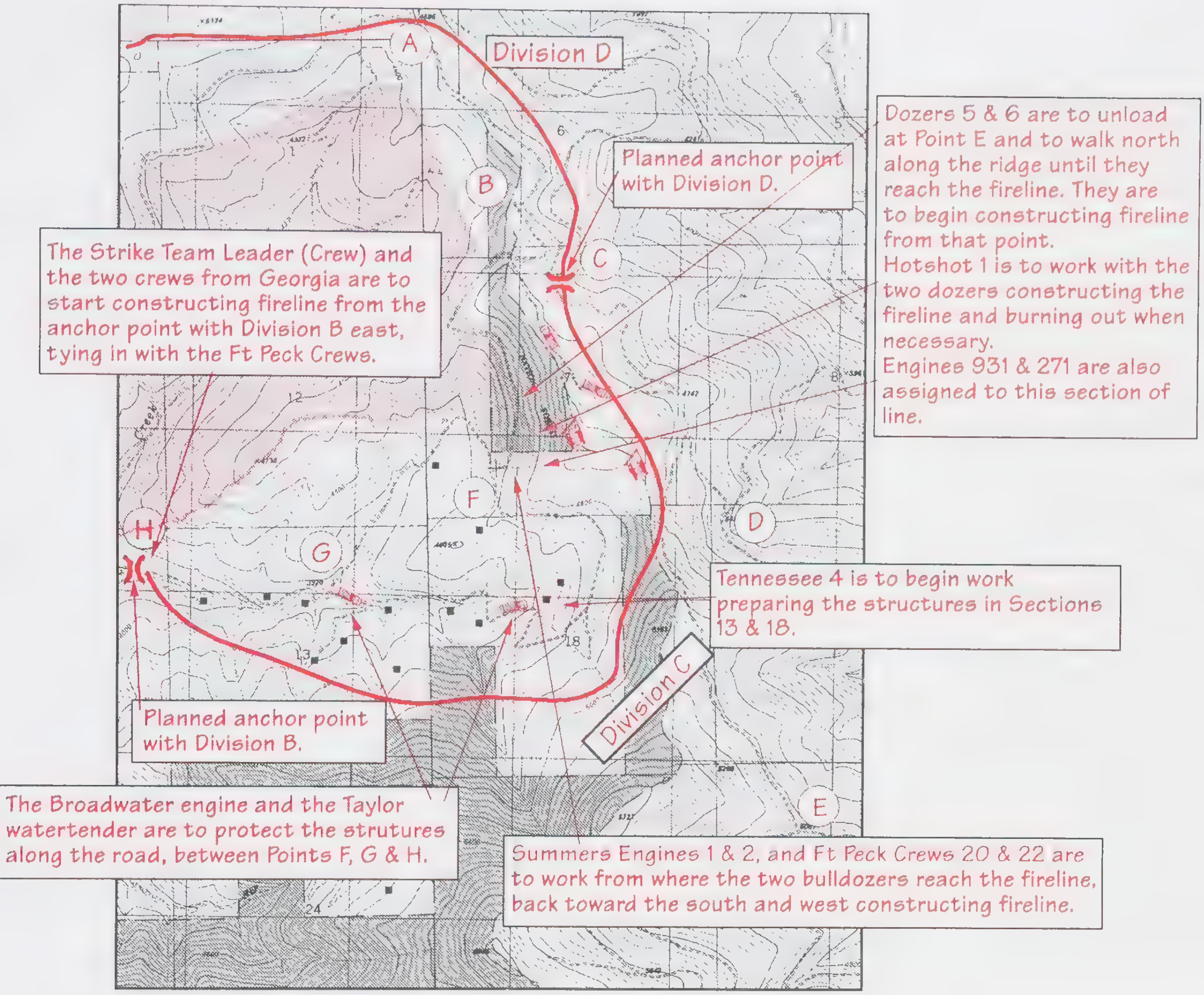
Possible Solutions: Two different solutions to this fire are presented. The first strategy focuses on fireline construction, with limited structural protection. The second strategy focuses on structure protection and a plan to move the fire around the structures. After the structures are safe, fireline construction will be the main focus of the suppression effort.

A fire behavior prediction is not fact, just a guess where the fire will be.

Suppression Strategy 1 - The focus is on fireline construction.

The Division/Group Supervisor is very concerned with the weather forecast and the impact the passage of a weather front will have on fire behavior. It is imperative that the fire behavior specialist remain on the fireline, monitoring the fire and taking weather readings intermittently. He is to provide the necessary warning if things are about to change.

The overall plan is to concentrate most of the firefighting resources on construction of fireline (Figure 11.23). There will be



Planned anchor point with Division D.

Dozers 5 & 6 are to unload at Point E and to walk north along the ridge until they reach the fireline. They are to begin constructing fireline from that point.
Hotshot 1 is to work with the two dozers constructing the fireline and burning out when necessary.
Engines 931 & 271 are also assigned to this section of line.

The Strike Team Leader (Crew) and the two crews from Georgia are to start constructing fireline from the anchor point with Division B east, tying in with the Ft Peck Crews.

Tennessee 4 is to begin work preparing the structures in Sections 13 & 18.

Planned anchor point with Division B.

The Broadwater engine and the Taylor watertender are to protect the strutures along the road, between Points F, G & H.

Summers Engines 1 & 2, and Ft Peck Crews 20 & 22 are to work from where the two bulldozers reach the fireline, back toward the south and west constructing fireline.

Figure 11.23 The plan is to construct direct fireline where possible and to prepare the structures.

some work preparing the structures in the area. The specific assignments are as follows:

- **Dozers 5 & 6** are to unload at Point E and walk the bulldozers north toward the east flank of the fire. They are to construct a safety zone either along the road or on the ridge. Their assignment is to construct direct fireline along the eastern flank of the fire toward the anchor point with Division D (Point C) if possible. If this isn't possible, they can fall back to the ridge line that runs between Points B and D and construct indirect line.
- **Hotshot 1** is to provide a dozer boss to work with the two bulldozers. The hotshot crew is to work with the two bulldozers on the east flank. They are to complete the development of the safety zone, and then, as necessary, burn out the fuels between any indirect fireline and the main fire.

Fireline will be constructed, working in three different directions.

- **Engines 931 and 271** are also assigned to the east flank of the fire. They are to work with Hotshot 1, as needed. The engines are to establish a water source in the area. If one can't be found, they are to set up a porta-tank that the Taylor water tender can supply. The hotshot crew leader will be responsible for coordinating all actions on this segment of fireline.
- **Fort Peck Crews 20 and 22** are to construct fireline back to the south and west, from the point at which Dozers 5 and 6 hit the fireline and head north. The crew leader on Fort Peck Crew 20 is given responsibility for this segment of fireline.

Develop small working groups.

- **Summers Engines 1 and 2** are to work with the two Fort Peck crews on the southern edge of Division C. If the terrain is such that the engines will not be of any use, they are to work on structure protection along the road between Points F, G, and H. The engines are also responsible for locating useful water sources in the area.
- **The Strike Team Leader (Crew), Georgia 1** and **Georgia FS 1** are to begin constructing fireline at Point H northeast toward the two Fort Peck crews. The Strike Team Leader is given responsibility for this segment of line.
- **Broadway Engine** and **Tennessee 4** are assigned to begin work preparing the structures in Sections 13 and 18. They are to advise any civilians they see to evacuate the area by moving west from Point H. The two Summers engines may also be assigned to assist in this task.
- The **Taylor Water tender** will be responsible for supplying water to all the operations on the division. When not shuttling water, they are to assist the Broadway engine crew with preparing structures.

You need multiple safety zones.

The personnel assigned to the eastern flank of the division are instructed to use the newly constructed safety island as their primary safety zone. Their second safety zone is located near the structure at Point F. The Fort Peck crews are told that their first choice of safety zones will be at Point F; their second safety zone is located at Point G. The personnel working along the road and up the fireline from Point H are told that there are safety zones at Points H, G, and F.

The Fire Behavior Specialist will be responsible for monitoring the weather and reporting to the Division/Group Supervisor any change that might signal an increase in fire behavior. The personnel assigned to the division are told that if a weather front moves through the area or the humidity drops to 20%, they are to immediately proceed to their safety zones and wait for further instructions.

Appoint someone to take the weather and monitor fire behavior.

Suppression Strategy 2 - The focus is on structure protection and a plan to take the fire around the structures.

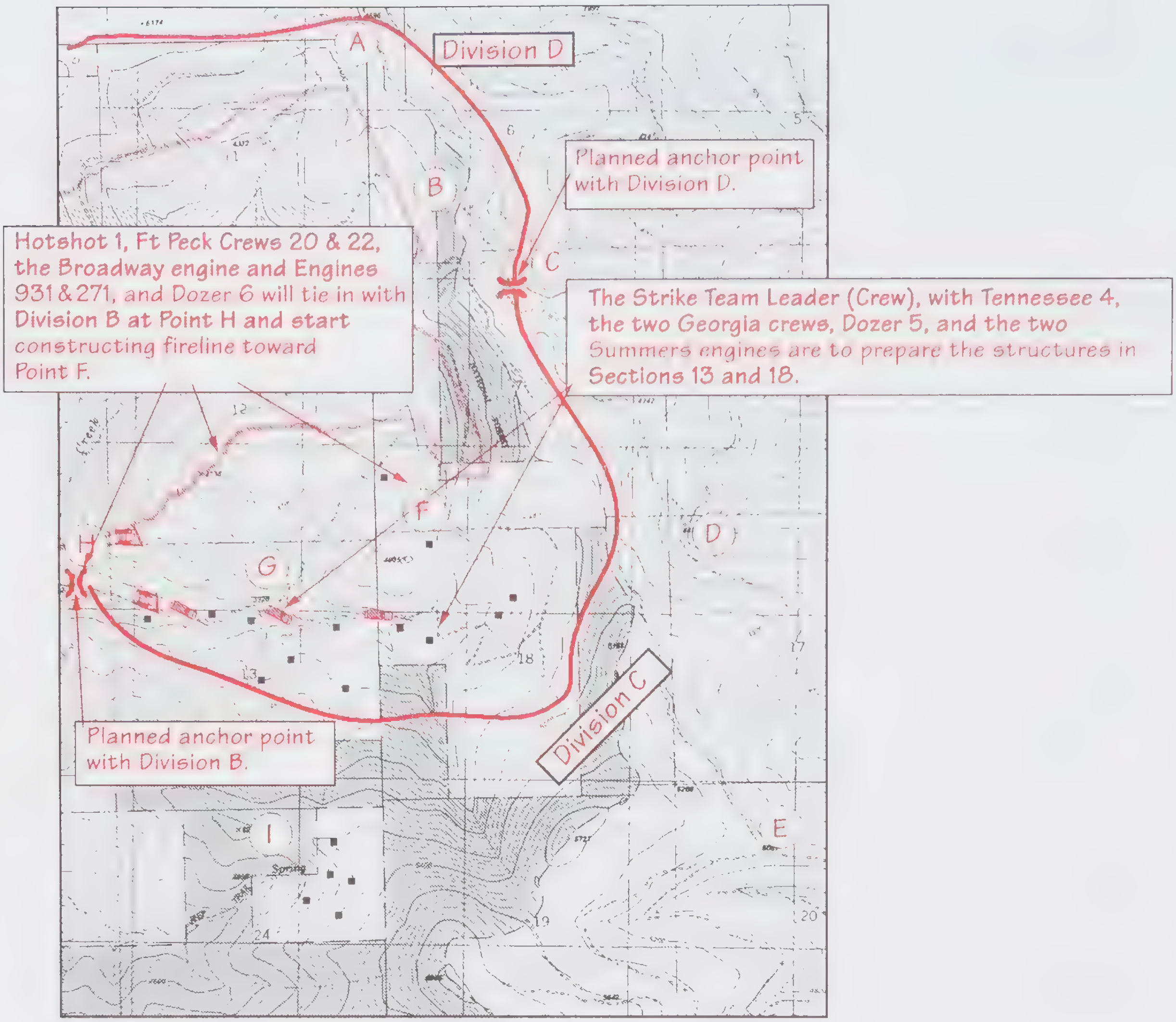
The Division/Group Supervisor meets with the Division B supervisor at Point H to discuss the plan. Since most of the eastern flank of the fire is open, the plan is to anchor Division C at Point H and to move east with a direct attack (Figure 11.24). The strategy is to move the fire around the threatened structures. In addition, considerable effort will be applied to preparing the numerous structures for defense. The specific assignments are as follows:

- **Hotshot 1, Fort Peck Crews 20 and 22**, the **Broadway Engine, Engines 931 and 271, the Taylor Water tender,** and **Dozer 6** are to tie in with Division B at Point H and start constructing direct fireline to the east towards Division D. The hope is that the fire can be turned, and thus moved around the structures located in the canyon below the fire. If this action does not appear to be working, and it is necessary to go into a totally defensive mode, this force (minus Dozer 6) will be moved to a position where they can protect the structures on the private land near Point I.
- The **Strike Team Leader (Crew), Tennessee 4, Georgia 1** and **Georgia FS 1, Dozer 5,** and **Summers Engines 1 and 2** are all assigned to prepare and defend the structures in Sections 13 and 18. They are told that safety islands exist at Points G and H, and that if firefighters or civilians must evacuate, they are to proceed west along the road toward Point H. The Strike Team Leader is given the responsibility for coordinating the actions in this segment of Division C. Once the structures are prepared, several of these units could be reassigned to line construction, starting from an anchor point with Division D and working back toward Point H.

Structure protection is given the priority. Fireline will be constructed in an attempt to move the fire around the structures.

Once the structures are secured, line construction will begin in earnest.

Given the weather forecasts, the Division/Group Supervisor doesn't have a high degree of confidence in this action. He considers it imperative that the Fire Behavior Specialist situate



Hotshot 1, Ft Peck Crews 20 & 22, the Broadway engine and Engines 931 & 271, and Dozer 6 will tie in with Division B at Point H and start constructing fireline toward Point F.

Planned anchor point with Division D.

The Strike Team Leader (Crew), with Tennessee 4, the two Georgia crews, Dozer 5, and the two Summers engines are to prepare the structures in Sections 13 and 18.

Planned anchor point with Division B.

Figure 11.24 This plan focuses on structure protection. Some fireline will be constructed, attempting to force the fire to move around the structures.

At the slightest hint the weather front is moving into the area, move the crews to safety.

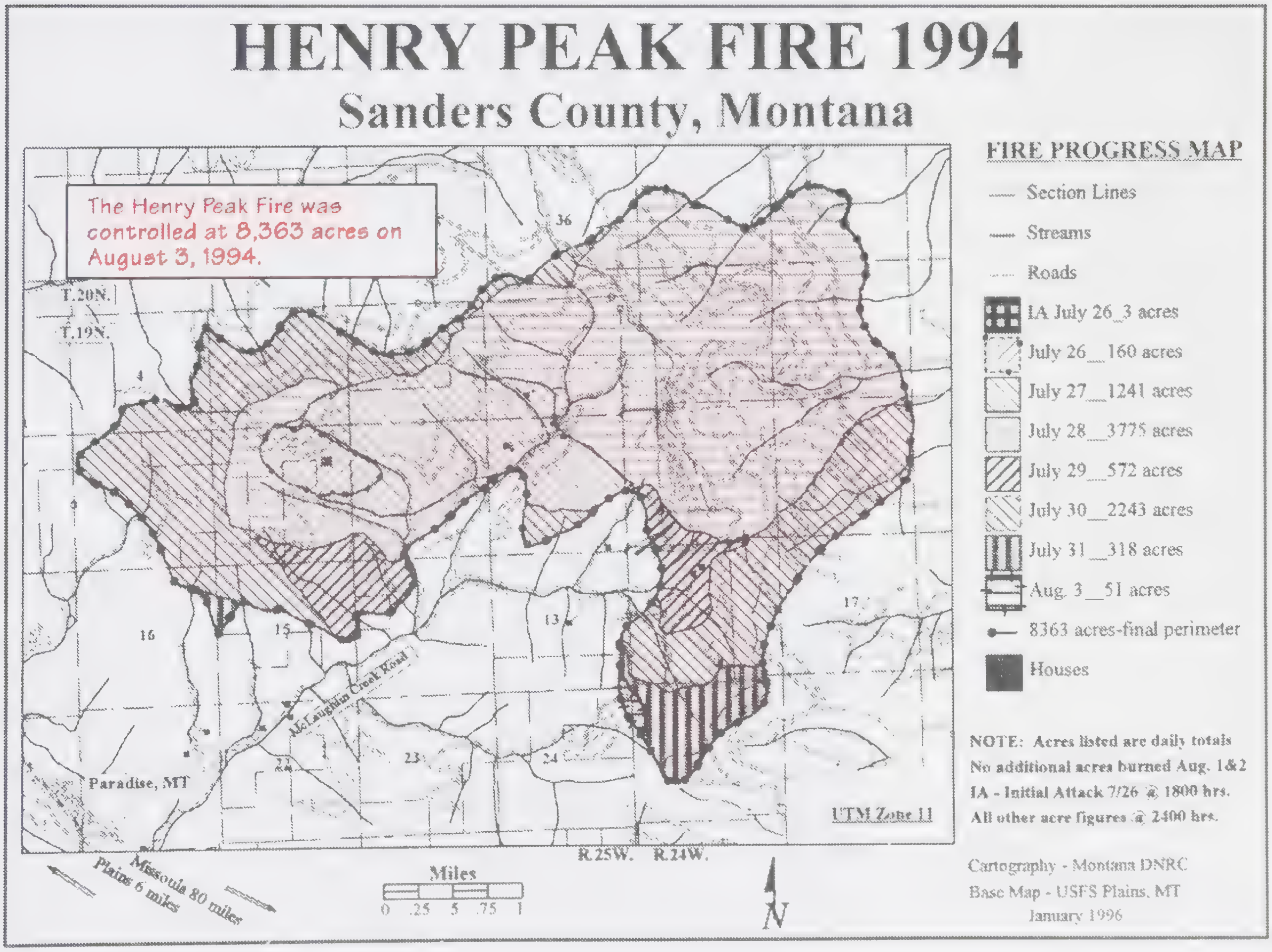
himself in a location where he can monitor the weather and fire behavior, and report any changes to him and to the various crews on Division C. At the slightest indication that a weather front is moving into the area, crews will be moved to safety islands until the front passes. Another concern is that some of the firefighters are not from the area and more than likely aren't experienced with these fuel types, terrain, and weather conditions. Special precautions will be necessary, such as closer supervision, a detailed briefing on what this weather pattern can bring, etc. The following is a discussion of the Henry Peak Fire on which this scenario was based.

Henry Peak Fire

The Henry Peak fire started at about 1800 hours on July 26, 1994, three miles northeast of Paradise, Montana. It was controlled eight days later, after burning 8,363 acres (Figure 11.25).

The actual strategy used on Division C on the Henry Peak Fire was to work the eastern flank of the fire with airtanker drops, bulldozers, and handcrews in a direct attack (Figure 11.26). The fire was backing down through logging slash with flame lengths of four feet or more, torching trees occasionally. The crew assignments for July 29th match those listed in Figures 11.16 and 11.17. The following additional resources were brought in the next day:

1 Type 1 Crew
8 Type 2 Handcrews
2 Strike Team Leaders (Crew)
2 Bulldozers
1 Safety Officer
1 Field Observer


HENRY PEAK FIRE 1994
Sanders County, Montana
FIRE PROGRESS MAP
Section Lines
Streams
Roads
IA July 26_3 acres
July 26_160 acres
July 27_1241 acres
July 28_3775 acres
July 29_572 acres
July 30_2243 acres
July 31_318 acres
Aug. 3_51 acres
8363 acres-final perimeter
Houses
T.20N.
T.19N.
36
4
9
16
15
13
17
22
23
24
McLaughlin Creek Road
Paradise, MT
UTM Zone 11
R.25W.
R.24W.
Plains 6 miles
Missoula 80 miles
Miles
0 .25 .5 .75 1
N

The Henry Peak Fire was controlled at 8,363 acres on August 3, 1994.

NOTE: Acres listed are daily totals
No additional acres burned Aug. 1&2
IA - Initial Attack 7/26 @ 1800 hrs.
All other acre figures @ 2400 hrs.

Cartography - Montana DNRC
Base Map - USFS Plains, MT
January 1996

Figure 11.25 The Montana DNRC controlled the Henry Peak Fire on August 3, 1994.

The fire moved south about a mile on the 29th and on the 30th it moved southwest, burning over 2,000 acres. A direct attack was used until the 31st, when they switched to an indirect attack, with several additional bulldozers. All through this period, the weather continued to be a major problem for the firefighters.

The fire in Division C moved about a mile east and three miles south before it was contained.

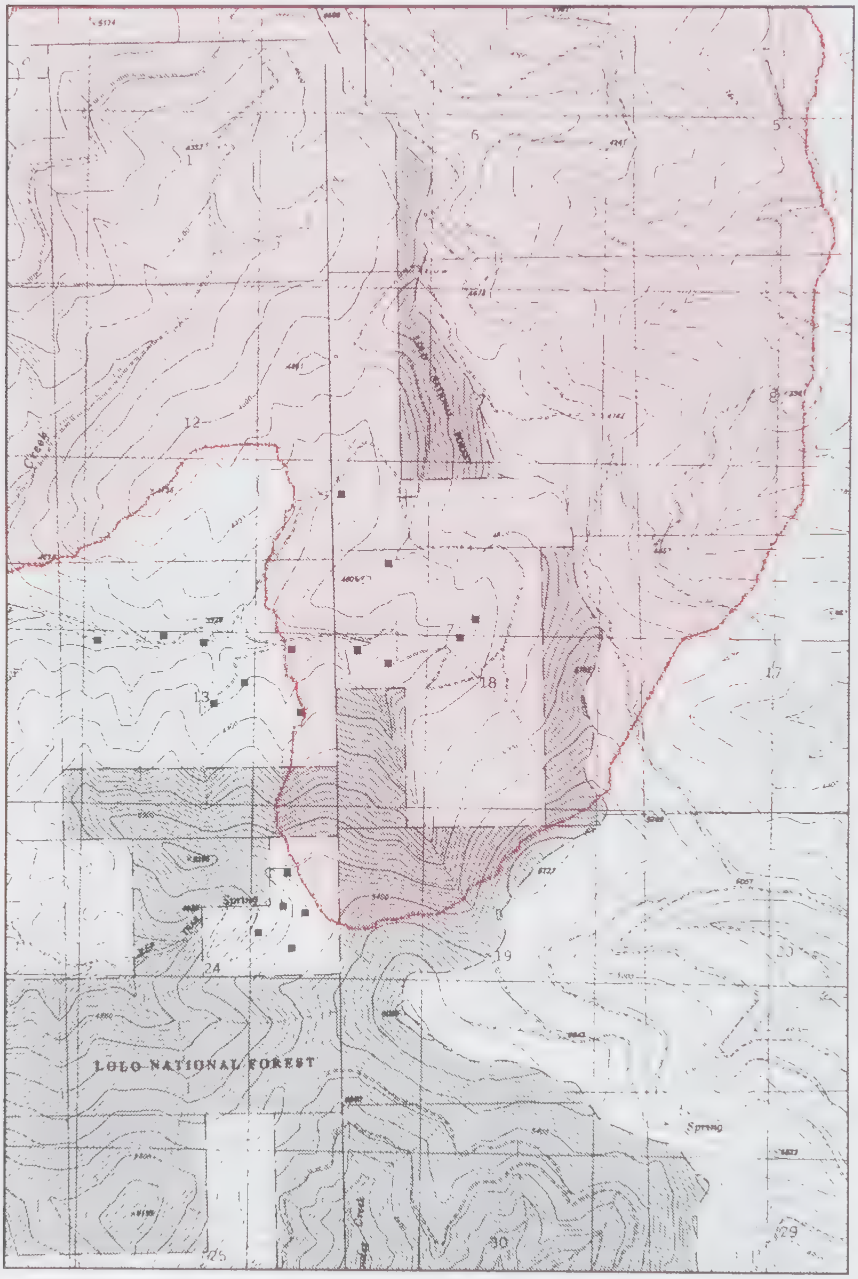

1
6
5
8
12
Creek
7
18
17
13
24
19
20
Spring
LOLO NATIONAL FOREST
Spring
25
30
29

Figure 11.26 The final line in Division C was placed east of the location where this situation developed.

Firefighting Situation 4

You are the Incident Commander on a fire in the Northern Rockies that is burning in timber and slash. Several summer cabins are in the area, but are not threatened at the present time. The fire started in the bottom of the canyon, near the road (Point A) at 1400 hours (Figure 11.27). It spread up the slope to the top of the ridge (Points E - F) by 1600 hours. You arrive at the fire at about 1700 hours. The fire is approximately 80 acres in size and has crossed the ridge.

You are the IC on a timber fire in the Northern Rockies.

The weather has been warm and dry. The wind at the origin is up-canyon at about 5 miles per hour, whereas the general wind across the ridges is southeast at about 15 miles per hour. The relative humidity is 18% and the fuel moisture is 4%.

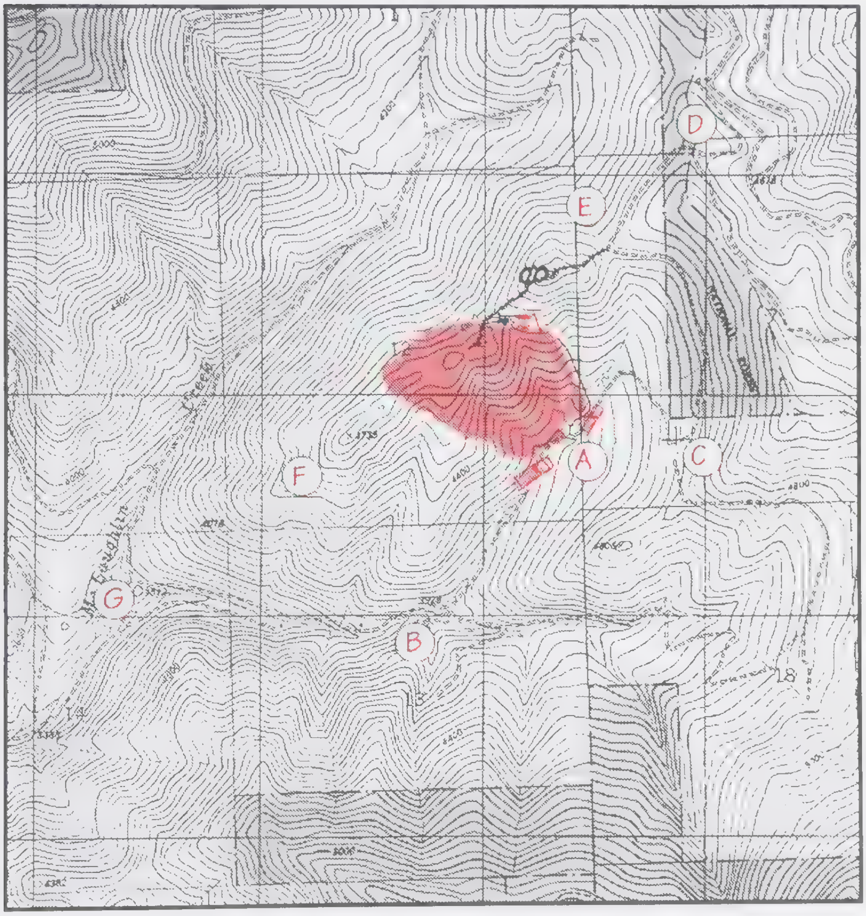


Figure 11.27 *This is a map of the fire at the time of your arrival. The first engine to arrive has started a hose lay up the right flank of the fire. The timber company bulldozer moved above the fire, but was not able to stop the fire before it crossed the ridge.*

The first attempt to cut the fire off on the ridge failed.

You will have to fight this fire with limited resources.

This is not the only fire burning in the area. You will only be able to get airtanker drops if the situation becomes critical.

It's hot and dry.

Situation: You meet with the initial attack IC at Point B. He gives you a topographic map. The resources committed to the fire are:

1 Type 3 engine with four firefighters.
3 Type 5 engines with a total of seven firefighters.
1 Medium bulldozer owned and operated by the landowner.
2 Type 2 handcrews (one of the crews will not arrive for several hours).

Because of the limited resources, not much fireline has been constructed. The original objective was to construct fireline on the ridge above the fire between Points E and F with the bulldozer, but the fire won the race and that line was not completed. However, it is now possible to drive equipment from Point E to the saddle near the center of Section 12.

A hose lay is being used to attack the right flank of the fire.

The Type 3 engine and one of the Type 5 engines have started a hose lay up the right flank. They are about half way up the slope to about the 4480-foot contour line. The Division Supervisor (leader on the Type 3 engine) says the line is holding, but will have to be cold trailed.

The landowner is very concerned about the loss of timber.

You meet with a representative of Cherry Creek Lumber Company, the landowner. The company requests that no more timber than necessary be burned. They can only provide limited assistance, because they are committed to several fires elsewhere on their property. They state that they may be able to provide a water tender. They will get back to you. You ask for and receive a spot weather forecast from the National Weather Service.

You contact your dispatch office and ask about the availability of additional resources. You mention that if you are to keep the fire as small as possible, it will take the commitment of considerably more resources. Dispatch informs you that no resources are available right now, but may be by mid-afternoon tomorrow. When you finish talking with dispatch, they transfer your call to the Fire Management Officer. The FMO briefs you on the overall situation and tells you, "Your fire is not threatening homes like

```
     NATIONAL WEATHER SERVICE
     SPOT FIRE WEATHER FORECAST
     CREEK FIRE
     5:30 PM MST

     DISCUSSION: THE PRESENT WEATHER PATTERNS WILL
CONTINUE FOR THE NEXT SEVERAL DAYS. THE AIR WILL
REMAIN DRY AND THERE WILL BE LIMITED RELATIVE HUMID-
ITY RECOVERY DURING THE NIGHT.

     TONIGHT...
       WEATHER:  CLEAR AND MILD
       TEMP/RH:  LOW TEMPERATURES IN THE HIGH 60S
WITH RH REMAINING BELOW 30%. GENERAL WINDS WILL
CONTINUE TO BLOW FROM THE SOUTHEAST FROM 10 TO 20
MPH. DOWN CANYON WINDS WILL BE 5 TO 8 MPH DECREASING
ABOUT MIDNIGHT.

     TOMORROW...
       WEATHER:  CLEAR AND WARM
       TEMP/RH:  TEMPERATURE WILL BE UP 3 TO 5°, RH
DOWN 3 TO 6%; FUEL MOISTURE 4%.
       WIND:  NO CHANGE.
```

The weather report says it is going to stay hot and dry for a while.

several of the other fires, and you have a relatively low priority. Make do with what you have if you can." You do get the FMO to approve the commitment of one additional 20-person handcrew and two structural engines from the state's mutual aid system. These resources will arrive sometime tomorrow morning.

Your fire is low on the priority list.

Solution Required: You now sit down with the initial attack IC and develop your plan. As the Incident Commander you are to:

- Develop your objectives.
- Outline the various tasks that need to be done, time-tagging each event or task.
- Address the need for rest periods for your limited forces.
- Decide what to tell the landowner.

Possible Solutions: Two very different strategies will be presented, one that deals with a direct attack in an effort to keep the fire as small as possible and the other an indirect attack because of the limited firefighting resources that are available.

How will you fight the fire,and keep the damage to the timber at a minimum?

Suppression Strategy 1 - A direct attack.

After the meeting with the initial attack Incident Commander, the new Incident Commander begins to develop her plan. Considering the weather, fire behavior, dry conditions in the area, lack of firefighting resources and heavy fuels, she selects a "safe" approach: to work a direct attack, concentrating on a flanking action. The general objectives for the fire are:

- Keep the fire from crossing the road to the south.
- Keep the fire from moving east toward the National Forest lands.
- Keep the fire from moving over the ridge and into the McLaughlin Creek drainage (Points G to H).
- Keep the fire from moving beyond the ridge between the saddle in the center of Section 12 to Point B.

A direct attack seems to be the best choice.

The fire is to be divided into three divisions. Division A will be the right flank, from Point A to the ridge line (Points E to F). The crew leader on the Type 3 engine will be "Division A." Division B will be the left flank, from Point A to the ridge. The crew leader on one of the Type 5 engines will be "Division B." Division C will be the ridge line between Points E and F. The crew leader on one of the Type 5 engines will be "Division C."

The IC tells dispatch that she is now in charge and that a water tender may be provided by the landowner. She then confirms the ETAs of the equipment not yet at scene and places the following order:

Flank the fire from the origin and catch the fire as it moves over the ridge.

1 Division/Group Supervisor
1 Fire Behavior Specialist
1 Support Unit Leader
1 Safety Officer

She would like to order more resources, but has already been told that no additional resources will be available for at least 24 hours.

The IC meets with the crew leaders to brief them on the weather forecast, the objectives, and the strategy that will be used to control the fire. Some of the points of that briefing are:

- There are several safety concerns: snags, rolling material and the location of the safety zones. It was decided that all personnel on Divisions A and B would use the log landing at Point A for their safety zone. The secondary safety zone would be at Point G. Division C was instructed to have the bulldozer construct two safety zones, one near Point E and one close to Point F. Division C personnel would move out of the area via Point D, if needed.

- It was also decided that working at night would be dangerous in this fuel type, so personnel would be pulled off the line about 2200 hours for feeding and rest.
- The best lookout in the area is at Point C. The ICP will be located there.
- There appears to be a water source at Point G. The landowner may be able to provide a water tender.
- The rest area for the fire will be at Points A and B. Crew leaders are to advise which one they will be using.
- Division A will be staffed with the Type 3 engine and a Type 5 engine. They are to advance the hose lay toward the ridge until they meet forces from Division C. They are advised to be alert to the safety concerns of working below a bulldozer.
- Division C is told that their first priority is to tie in with Division A. They are then to move toward Point F with their line construction. Division C will have one Type 5 engine and the bulldozer. The next in handcrew will also be assigned to them.
- Division B is told to start construction of fireline up the left flank, anchoring the line at the road. One Type 5 engine and a handcrew are assigned to Division B.

Crews will be pulled off the line at night, for safety and to rest.

The fire is divided into three divisions.

The IC uses a topographic map to discuss the plan in greater detail with the crew leaders (Figure 11.28).

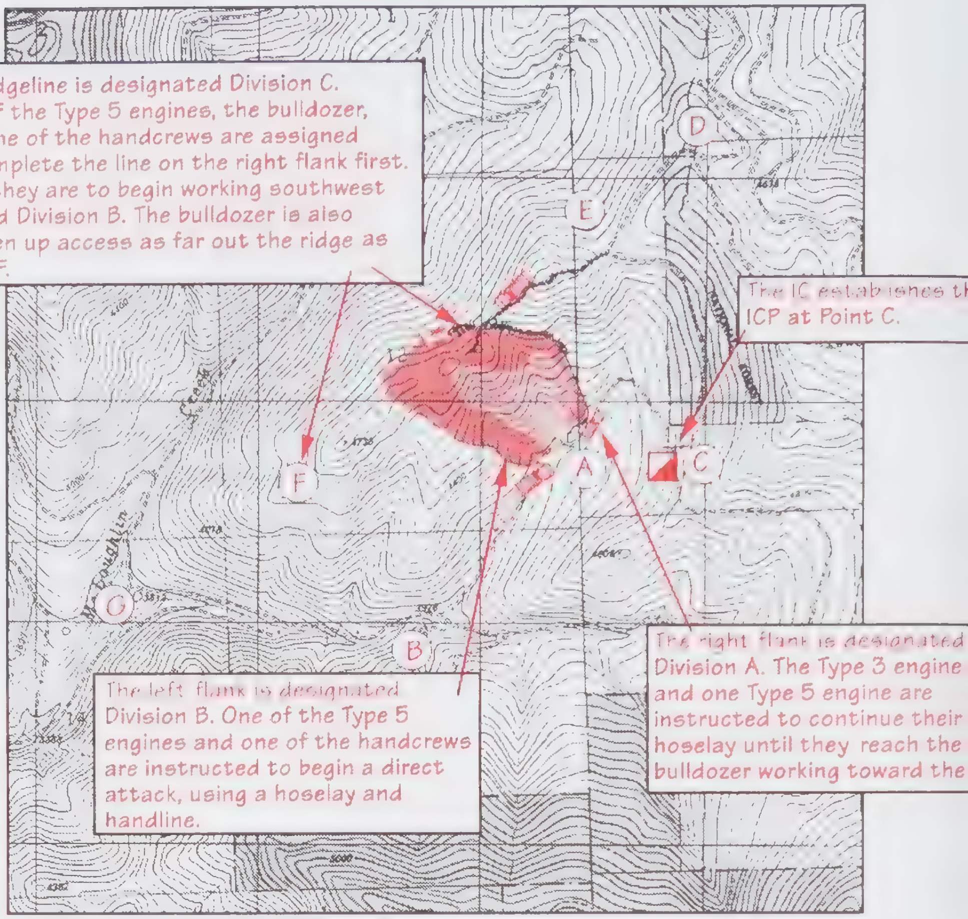
The crews will be rested from about 2300 hours to 0500 hours the next morning. The crews will then be fed, and the situation will be reassessed. If weather conditions hold as predicted, they will continue with the same objectives and plan.

The IC meets with the representative from the timber company and briefs him on the situation and plan. She asks if he has any concerns with the overall plan.

The day shift for the next day is developed. Two Type 5 engines and a handcrew will continue to work the left flank on Division B. One of the Type 5 engines will be assigned to mop up and patrol the right flank on Division A. The remaining forces will be assigned to the attack on Division C. The two structural engines will be used to assist the activities on Divisions A and B. The incoming handcrew will be rested, if necessary, and then assigned as needed.

The day shift is on the line at dawn.

The priority is Division A's hoselay up the right flank.



The ridgeline is designated Division C. One of the Type 5 engines, the bulldozer, and one of the handcrews are assigned to complete the line on the right flank first. Then they are to begin working southwest toward Division B. The bulldozer is also to open up access as far out the ridge as Point F.

The IC establishes th
ICP at Point C.

The left flank is designated Division B. One of the Type 5 engines and one of the handcrews are instructed to begin a direct attack, using a hoselay and handline.

The right flank is designated Division A. The Type 3 engine and one Type 5 engine are instructed to continue their hoselay until they reach the bulldozer working toward the

Figure 11.28 The plan is outlined to the crew leaders using a topographic map.

Suppression Strategy 2 - An indirect attack.

The incoming Incident Commander meets with the Initial Attack Incident Commander at Point A. They discuss the actions to this point and the spot weather forecast. They both agree that a fire in heavy fuels, under the predicted weather conditions, and with the limited resources, will be difficult to contain using a direct attack. The decision is made to develop a plan that backs off from a direct attack to one using existing barriers when possible. The bulldozer will be used to construct fireline on the north-east part of the fire. This plan will burn considerable acreage, but under the circumstances, the Incident Commander doesn't feel he has a choice.

The IC plans an indirect attack. A large area will be burned, but the fireline will be much easier to construct.

The following objectives are established for the fire:

- Provide for both firefighter and public safety at all times.
- Confirm the location of any structures or improvements in the area by 2100 hours.

- Contain the fire to an area west of the National Forest, north of the road (Points A, B, and G) and south of the road (Points G to H), by 2400 hours tomorrow.
- Minimize the damage to timber.

Objectives stress firefighter safety.

The Incident Commander locates his ICP at Point G. There is enough space at this site to also accommodate a staging area and the limited incident base operations. The IC contacts dispatch and informs them of the location of the ICP, staging, and the incident base. He also confirms that the name of the incident will be "McLaughlin" and that he is now "McLaughlin IC" (Figure 11.29).

The fire will be divided into three divisions. Division A will be from the road near the origin (Point A) up the right flank to Point E and beyond to Point H. The crew leader on the Type 3 engine will be "Division A." Division B will be that segment of line from Point G to H. The crew leader on one of the Type 5 engines will be "Division B." Division C will run along the road south of the fire from Point A to Point G. Again, the crew leader on one of the Type 5 engines will be "Division C."

The fire is divided into three large divisions.

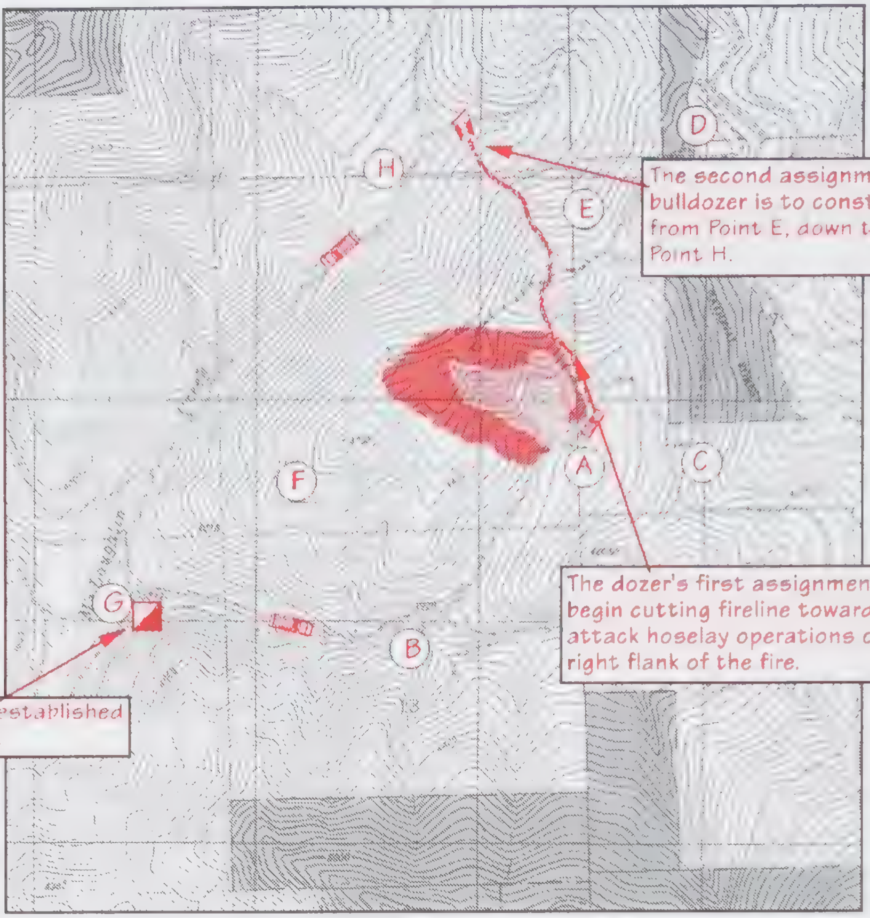
The overall plan is to use the bulldozer to construct fireline from the ridge line at Point E back toward the origin at Point A. The bulldozer will then construct fireline from Point E, north down the ridge to Point H. This is all to be completed by 0300 hours. Once this line is completed, there will be four phases to the firing out of over 600 acres of timber (Figure 11.30).

The IC meets with the representative of the landowner and outlines the plan. He explains that because of the limited resources available, he has elected to go with an indirect attack. The landowner is concerned that over 600 acres will be burned, but realizes that if a direct attack was to fail, the fire might cross McLaughlin Creek to the north and become much larger.

The bulldozer will be used to construct fireline from the origin, up and over the ridge to the road to the north.

The first phase (1) of the firing will be that segment of Division A between Points A and E (Figure 11.30). This is to be burned by 2100 hours. The second phase (2) of the firing will be accomplished later in the evening, between Points A, B, and G. This is to be accomplished by 2200 hours. The next phase (3) will

The ICP and Staging are located together.



The second assignment for the bulldozer is to construct fireline from Point E, down the ridge, to Point H.

The dozer's first assignment is to begin cutting fireline toward the initial attack hoselay operations on the right flank of the fire.

The ICP is established at Point G.

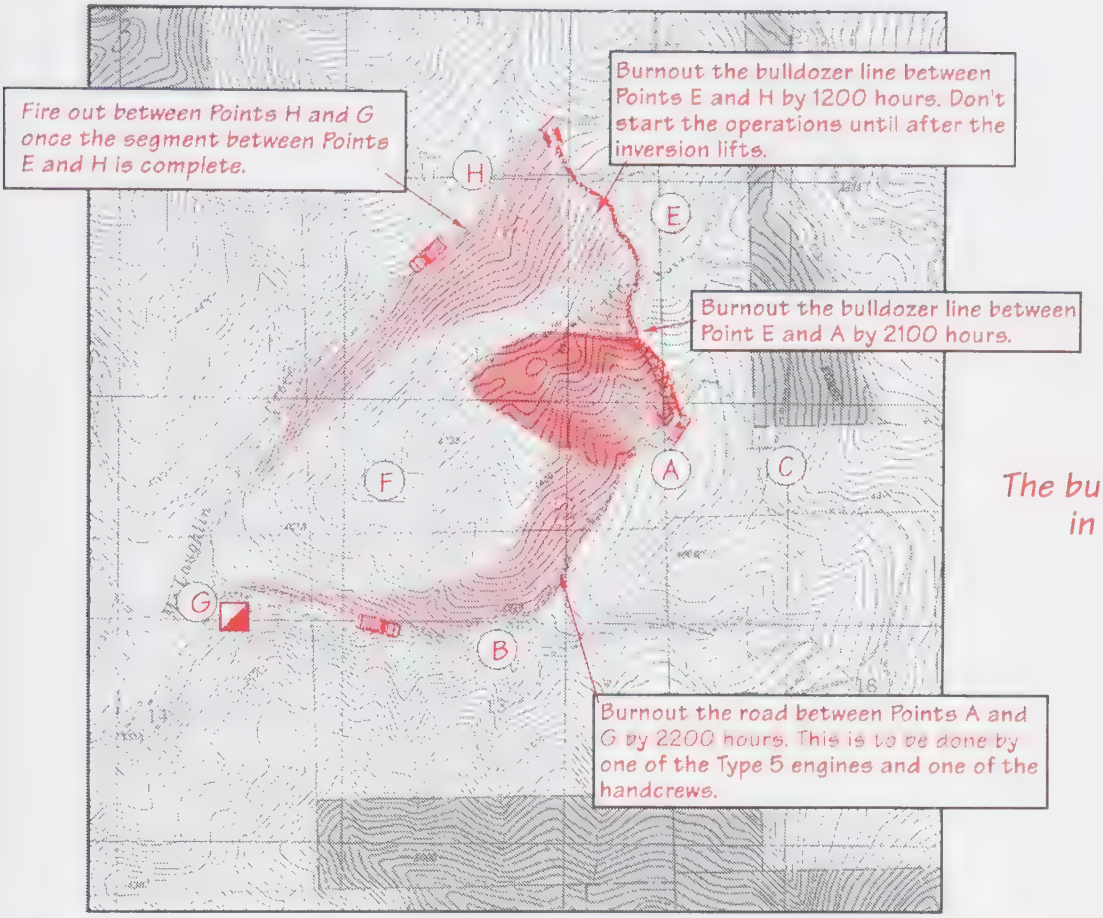
Figure 11.29 An indirect attack strategy has been selected. The bulldozer will construct fireline between Points A, E, and H. This line and the roads will be fired, completing the containment of the fire.

The IC plans to burn off the whole point, using the existing roads as fireline.

be the remaining segment of Division A, between Points E and H. This is to be burned after the inversion layer lifts tomorrow morning; it is to be accomplished by 1200 hours. The remaining phase of the burning (4) is to be the road between Points H and G. It is hoped that all of the burning will be completed by mid-afternoon and mop-up can begin.

The two structural engines will be held in staging for use in protecting structures if that becomes a reality, to provide medical aid services or, as needed, to mop up in Divisions B and C.

It is planned to have the fire contained by midnight of the second night and controlled by 1800 hours three days later.



Fire out between Points H and G once the segment between Points E and H is complete.

Burnout the bulldozer line between Points E and H by 1200 hours. Don't start the operations until after the inversion lifts.

Burnout the bulldozer line between Point E and A by 2100 hours.

Burnout the road between Points A and G by 2200 hours. This is to be done by one of the Type 5 engines and one of the handcrews.

Figure 11.30 The firing sequence is important and should be coordinated.

The burning will be done in four phases.

The burning operations will have to be well coordinated.

Firefighting Situation 5

You are the Battalion Chief for a small city in the Bay Area of California. You are the Incident Commander on a fire that has been contained at 60 acres of grass and light brush (Figure 11.31). The fire is totally within the city. There is only one engine available within the city to answer new calls (normally there are three).

You have called in mutual aid from the surrounding jurisdictions. The forces on the fire are:

2 Type 1 engine companies from your city.
1 Type 3 engine company from your city.
2 Type 1 Engine Strike Teams from various cities.
2 1,500 gallon water tenders from your city.
2 Type 3 engine companies from state forestry.
1 handcrew from state forestry.

You have contained your fire, but the winds are picking up.

This weather forecast matches the one the day of the Tunnel Fire, that killed 25 people and destroyed over 3,000 homes.

```
     NATIONAL WEATHER SERVICE
     FIRE WEATHER FORECAST
     0930 AM PDT SAT OCT 19

     ***RED FLAG WARNING FOR DIABLO RANGE SOUTH OF MT
DIABLO TO LOS BANOS

     DISCUSSION: WARMING UP FOR STRONGER NORTHERLY
WINDS AND LOWERING HUMIDITIES. RED FLAG WARNING UP OUT
OF REDDING DISTRICT THIS MORNING AS WELL. PATTERN TO
HOLD INTO MONDAY MORNING THEN SWITCH AROUND AS NEW
TROUGH COMES INTO COAST. STILL WINDY FIRST OF WEEK BUT
FROM SOUTHWEST.

     TODAY...
       WEATHER: FAIR AND WARM
       TEMPERATURES: UP 2 TO 6 DEG.
       RELATIVE HUMIDITY: DOWN 4 TO 8%
       PEAK/RIDGE WINDS: NE TO NW 15 TO 25 AND GUSTY
       LOWER LEVEL WINDS: UPSLOPE/UPCANYON 4 TO 8
       GUSTING TO 15 TO 20 ON NORTH TO EAST ASPECTS.

     TONIGHT...
       WEATHER: FAIR
       TEMPERATURES: UP 2 TO 4 DEG
       RELATIVE HUMIDITY: DOWN 3 TO 6%
       PEAK/RIDGE WINDS: E TO NE 15 TO 20 GUSTING TO 25
       INVERSIONS: WEAKER
       LAL: 1
```

Situation: It is early afternoon in the fall of the year. You have just been given the fire weather forecast printed above. You note that the weather has been close to what was predicted. The winds were not gusting to the predicted extent, but were generally from the north, at about 10 miles per hour. Several years earlier, you were on the Tunnel Fire disaster in Oakland. This is the same weather pattern that was occurring then!

You call your chief on the cellular phone to discuss the following concerns:

- The wind has become stronger, more closely matching the forecast.
- Conditions are similar to those at the time of the Tunnel fire.
- The impact of continuing to deplete local resources.
- The cost of suppressing the fire is totally the responsibility of the city.

This is going to be an expensive fire to fight. If it gets away, it will really be costly.

The chief advises you to put the fire out, and states, "I will meet with the city manager and develop a plan to deal with the costs. You just make sure the fire does not escape."

Solution Required: You are to develop a plan of action that will control the fire and keep it from escaping. You can request assistance from state forestry, other city departments, other cities, and from private contractors. All resources except those covered by mutual aid agreements will be charged to the city.

The chief says put it out!

Specifically, develop the following:

- A list of general objectives.
- A list of equipment that will be requested.
- A plan to provide logistical support.
- A plan if the predicted weather materializes and the fire does escape.

Possible Solutions: Two suppression strategies will be presented. In each case, the Incident Commanders understand the impact of the weather forecast and are developing plans to deal with the situation.

How are you going to organize your mop-up efforts?

Suppression Strategy 1 - Heavy immediate augmentation.

Even though the fire is contained, the weather on the fire is changing and the Incident Commander is very concerned. He scribbles out the general objectives for the fire:

- Hold fire west of populated areas.
- Hold fire south of Highway 24.
- Hold fire east of Skyline Blvd.
- Hold fire north of Eastport.

The fire is separated into two divisions. Division A is the right flank to the road between Points F and J. The fire captain on the city Type 3 engine is designated "Division A." Division B is from the origin along the road (Point B to E) to the south where it connects with Division A. The fire captain on the state Type 3 engine is designated "Division B." The initial attack and mutual aid resources are given the following assignments:

You develop a two division fire and staff it in anticipation that the fire may escape.

- Division A will be staffed with the city Type 3 engine, the state Type 3 engine, the city water tender, and the state handcrew. They are to use a flanking action with a mobile attack, hose lays, or hand line. They are to move to the south, and then east, until they tie in with Division B.

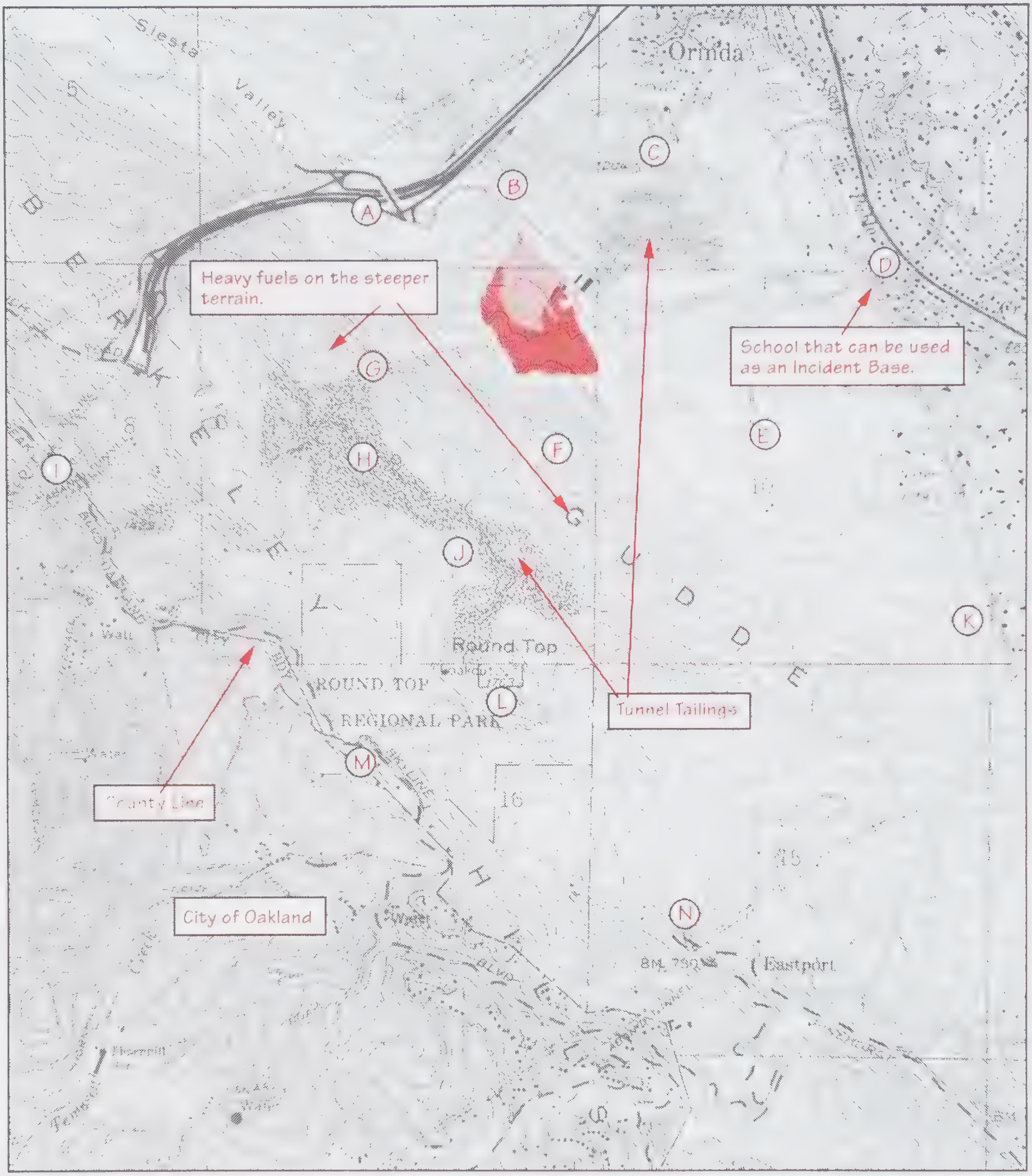

Orinda
Siesta
Valley
A
B
C
D
E
F
G
H
I
J
K
L
M
N
Heavy fuels on the steeper terrain.
School that can be used as an Incident Base.
Round Top
ROUND TOP
REGIONAL PARK
Tunnel Tailings
County Line
City of Oakland
SKYLINE
Eastport
BERKELEY
UDDE

Figure 11.31 Your map of the fire showing it contained at 60 acres. The areas south and west of the fire have not burned in years. Just over the hill to the west is the site of the Tunnel Fire.

- Division B will be staffed with the two city Type 1 engines, the state Type 3 engine, and a city water tender. They are to move west in a mobile attack, using the roads as fireline when possible. They can fire the road (Points B to E) if necessary.
- The two Type 1 Engine Strike Teams will be positioned in Staging at Point A. They will be used for structure protection, if that becomes necessary, and to cover new alarms within the city.
- The ICP is established at Point B.
- A lookout is positioned on the small hill at Point C. The lookout is to monitor the fire behavior and the weather.

You concentrate your efforts on the southwest flank.

You post a lookout on a high point to monitor the fire behavior and to record weather readings.

The Incident Commander is very concerned that if the wind picks up as predicted, he will have no way of holding the fire to the current 60 acres. The IC believes that it would not be wise to "nickel and dime" the fire. He is convinced that the fire will in fact escape, and that he needs to get as many resources as possible to take all of the heat out of the existing fire. He places the following order for resources:

10 Type 3 engines (the closest immediate response)
2 Type 2 or 3 fire agency bulldozers (the closest immediate response)
3 Type 1 handcrews
1 Air Attack Officer
4 Type 2 or 3 airtankers
2 Type 2 helicopters
3 Division/Group Supervisors
1 Staging Area Manager
1 Fire Information Officer

You place a large order.

The media pressure will be "monumental" very soon. The FIO is to relieve the IC of having to deal with it. An order for logistical support will be developed later in the day.

The general plan is to keep the fire in the lighter fuels and away from the steep terrain. An all-out effort will be made in Division A to meet this objective. If necessary, the fire will be allowed to move into the mining tailings (Point H) where it will be slowed. Secondary lines can be developed on the ridge that runs between Points E and L, and between Points B and G. The road (Points B, E, and K) will be used as the fireline if an expanded operation is necessary (Figure 11.32).

The news media pressure will be "monumental" very soon.

Air operations will be coordinated through the air attack officer. The airtankers will have a 35-minute turn around time. The helicopters can stage on the flat just east of Staging or Point A. The helicopters can refill at the water tank on the hill a half-mile southeast of Point E.

Several notifications to other agencies are made. Local law enforcement and Regional Park Fire Authority representatives are requested to report to the ICP. The fire authorities for the area south and west of the county line (Points I to M) are notified.

You request that representatives from law enforcement and nearby fire authorities to come to the ICP.

The IC asks that a full recall of city chief officers is made and that all reserve fire apparatus be staffed. Plans are made to establish another staging area on Skyline Boulevard. near Point M. Incident Base will be established at the school at Point D.

Suppression Strategy 2 - Moderate buildup with logistical support.

The Incident Commander is very familiar with the winds that may be in his future, so he develops plans for managing a larger fire. The following objectives are proposed:

- Mop up and hold the fire to 60 acres.
- Staff fire to prevent its escape after containment.
- Stage resources in anticipation of weather event.
- Provide logistical support to incident resources.
- Ensure incident base has the ability to rapidly expand.

The IC ordered a moderate buildup of resources. He also began to build a logistical organization.

All of the resources assigned to the incident are instructed to mop up the fire. Special efforts are to be made in the heavier fuels on the south side of the fire (Figure 11.33).

The IC briefs the dispatch center on the status of the fire. He is told that a Strike Team of Type 1 engines is positioned in the city to provide coverage and to assist if the fire escapes control. The IC places the following order:

1 Type 3 Engine Strike Team (the closest immediate response)
1 Type 2 Handcrew Strike Team (the closest immediate response)
1 Type 2 Handcrew (the closest immediate response)

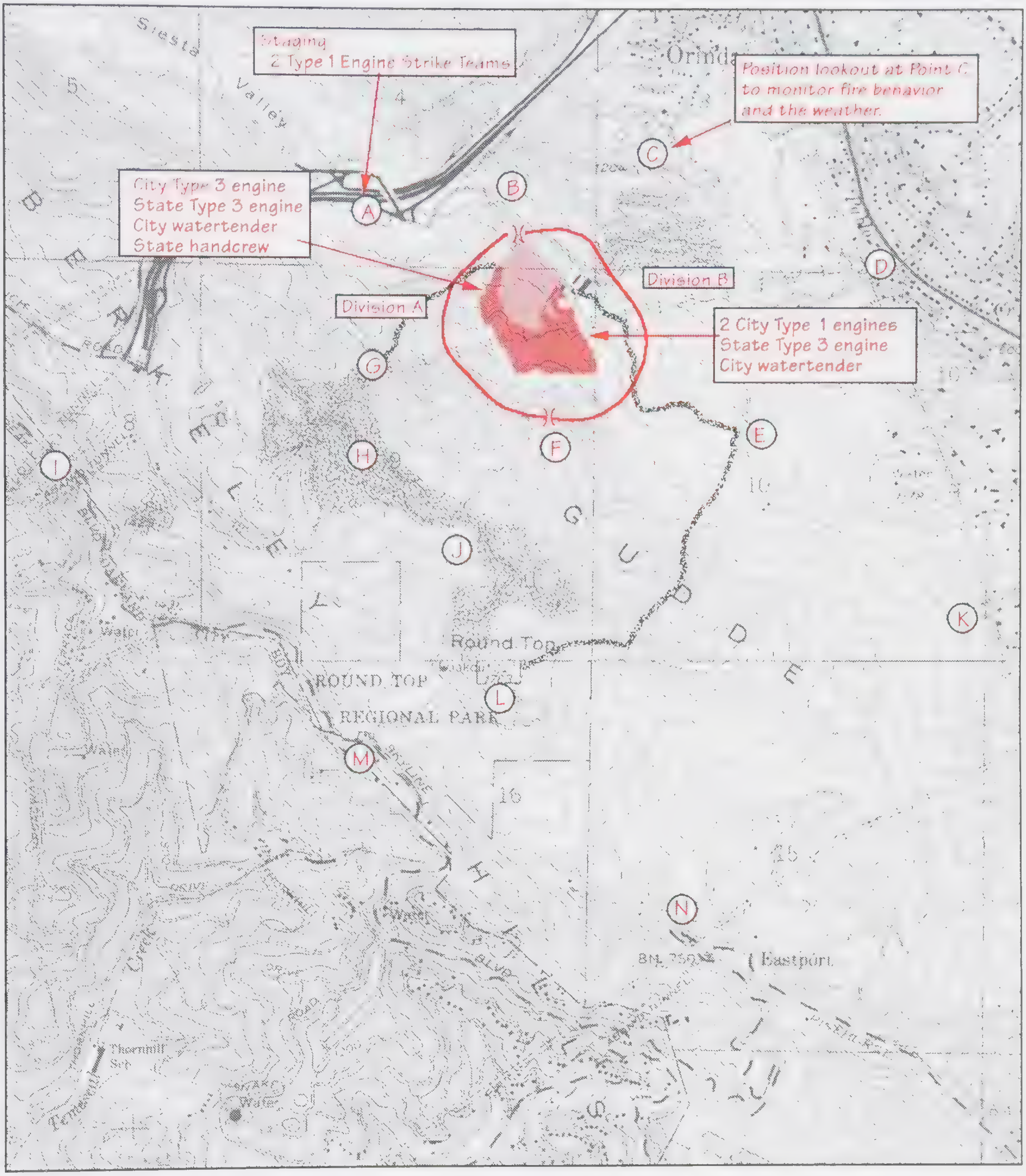

Staging
2 Type 1 Engine Strike Teams
Position lookout at Point C to monitor fire behavior and the weather.
City Type 3 engine
State Type 3 engine
City watertender
State handcrew
Division A
Division B
2 City Type 1 engines
State Type 3 engine
City watertender
A
B
C
D
E
F
G
H
I
J
K
L
M
N
Siesta Valley
Orinda
Round Top
ROUND TOP REGIONAL PARK
Eastport
16
15

Figure 11.32 The fire is separated into two divisions. Most of the effort will be placed on Division A, the right flank. This is the area most vulnerable for escape.

1 Division/Group Supervisor
1 Structural Group Supervisor
1 Fire Information Officer
1 Field Observer
1 Strike Team Leader (Crew)
1 Safety Officer
1 Planning Section Chief (Type 2)
1 Resources Unit Leader
1 Situations Unit Leader
1 Fire Behavior Specialist
1 Logistic Section (to staff a 200 person operation)
1 Staging Area Manager
1 Finance/Administration Chief

You establish an incident base and the logistical support to staff it.

The IC also places an order for resources that are to report to staging by 0600 hours tomorrow morning for the day shift. They are to be fed and rested prior to reporting to staging. The resources ordered are:

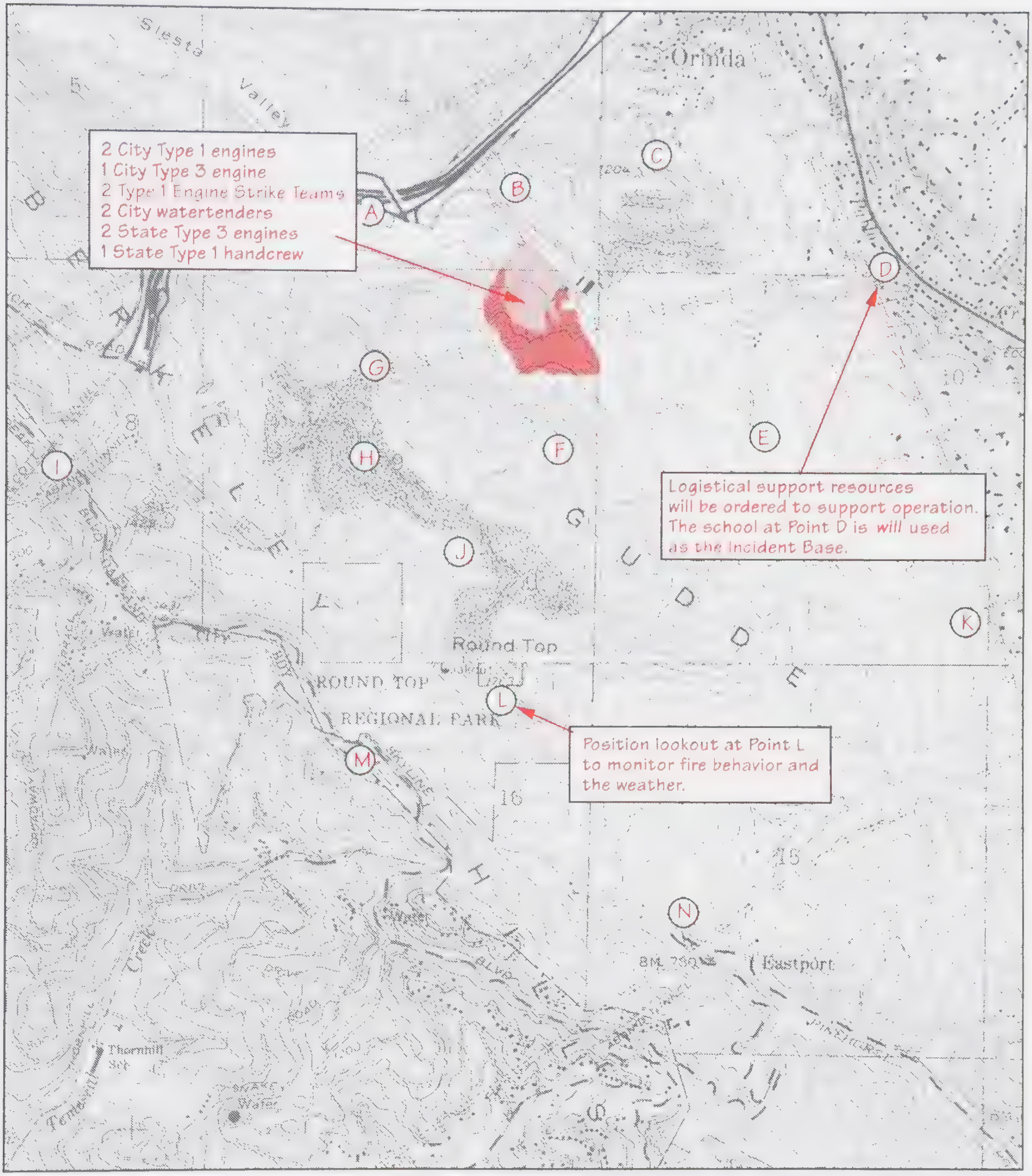
1 Type 3 Engine Strike Team
1 Type 2 Crew Strike Team
2 1,500 gallon water tenders
1 Division/Group Supervisor
1 Staging Area Manager
1 Structural Group Supervisor
1 Incident Commander

The IC's plan is to order the additional resources necessary to staff the fire for the rest of the day and the night shift. The two Division/Group Supervisors are being ordered to provide better supervision of the firefighting resources. The Field Observer is to be placed at the old lookout site on the ridge above the fire (Point L).

You order tomorrow's shift early.

The resources on the fire will be worked most of the night. If possible, some of the crews will be moved after midnight to the Incident Base for rest. The plan is to have the day shift on the line by 0700 hours.

The Incident Base will be established at the school east of the fire at Point D. There are adequate facilities and shade to rest the crews there. If the handcrews involve inmates, they can be rested in a small park several miles east of the Incident Base.


Orinda
Siesta
Valley
A
B
C
D
E
F
G
H
I
J
K
L
M
N
Round Top
ROUND TOP
REGIONAL PARK
16
15
10
Eastport
Creek
Thornhill
Sch

2 City Type 1 engines
1 City Type 3 engine
2 Type 1 Engine Strike Teams
2 City watertenders
2 State Type 3 engines
1 State Type 1 handcrew

Logistical support resources will be ordered to support operation. The school at Point D is will used as the Incident Base.

Position lookout at Point L to monitor fire behavior and the weather.

Figure 11.33 All of the resources assigned to the fire are placed on the fireline. A large order is made to support the mop-up operations and to provide logistical support.

The Planning Section Chief will be instructed to develop plans in the event the fire escapes. He is to coordinate his plan with the fire authorities south and west of the fire. Contingency plans are to be available by 0700 hours, when the IC will be briefing the City Manager and the Council. Following this briefing, the IC will turn the fire over to the day-shift IC.

The Planning Section Chief is instructed to come up with a plan. It is to be coordinated with the nearby fire agencies.

Firefighting Situation 6

You are the fire officer assigned to Engine 651. Just after 0900 hours, you are dispatched to a reported grass fire 2 miles north of Canyon Creek, on the west side of the road. When you arrive at scene you find about a half-acre of heavy grass burning slowly away from a well-drilling rig. Several people are working on the fire (Figure 11.34).

You tell dispatch that you can handle the fire and start a mobile attack, using a ¾-inch reel-line. You contain the fire with a wet-line at about 1 acre. You return to the origin to investigate the cause. The well-drilling workers say that the fire was an accident, started by sparks from a welder. The workers say that they will be shutting down the operation for the day. Before leaving the fire, you drive around it again, looking for "smokes." Finding none, you return to quarters (Figure 11.35).

Later in the morning you listen to the fire weather forecast. It is predicted that the temperatures will be in the 90s, relative humidity below 20%, and the fuel moisture will be around 4%. The winds will generally be from the north at about 10 miles per hour.

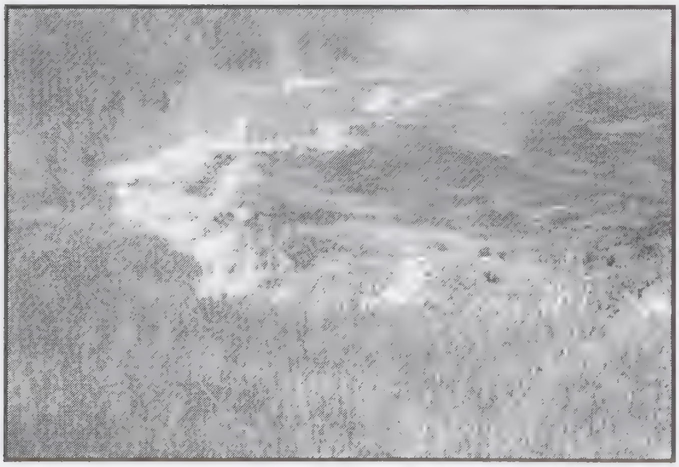


Figure 11.34 The fire is burning in grass.

Situation: You spend most of the morning maintaining equipment and conducting company-level training. At noon you notice that the weather forecast appears to be "right on." It is turning warm and dry, and the wind has shifted. At about 1400 hours, you are

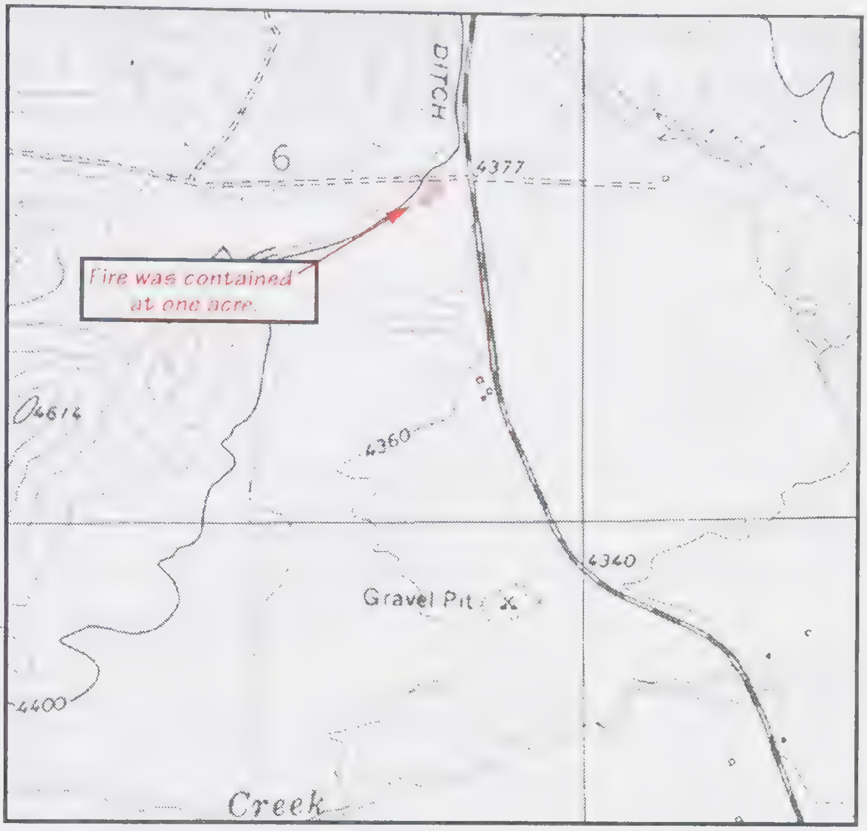


Figure 11.35 *The fire was contained at about 1 acre.*

An early morning grass fire is contained.

dispatched to a fire north of Canyon Creek. You are part of a three-engine response. (Note: All of the apparatus will be responding with two firefighters.) You can see the smoke as you leave the station. You note that it is white and is being pushed by a moderate wind.

The temperature is moving up and the humidity is dropping to below 20%.

When you arrive at scene, you find a grass fire burning in a southwesterly direction. The fire is in the same area as the one you worked earlier in the morning. You advise dispatch that the fire is about 30 acres and moving fast. There is one ranch on the left flank that may be in danger. You also note that the well-drilling personnel are still working on their rig. The fire is burning with moderate fire behavior, with four- to six-foot flame lengths at the head. You ask for a second alarm, specifying four engines, a water tender, and a bulldozer.

At 1400 hours a new fire is reported. It may be threatening a ranch complex.

Solution Required: You are the Incident Commander. The six additional engines will be arriving about one every 8 to 10 minutes. The water tender will be there in about 20 minutes. No bulldozers are available for hours. Specifically, you are to:

- Organize your attack.
- Protect the ranch buildings on the left flank.
- Make notes for a critique of both fires.

The fire is about 30 acres and is moving fast.

Possible Solutions: Three solutions will be presented for this fire scenario. The first one attacks the flank to protect the ranch complex; the second attack strategy places the first-in engine in the ranch complex to ensure protection; the third strategy attacks the right flank to keep the fire from burning into rougher terrain and heavier fuels, leaving the protection of the ranch complex to the second- or third-due engines.

Suppression Strategy 1 - A flanking attack to protect the ranch complex.

How will you protect the ranch complex?

As Engine 651 approaches the fire, the fire officer sees that the Grady Ranch complex is not in immediate danger, so he elects to attack the fire from the county road. His objectives are:

- Protect the ranch complex by making an aggressive attack on the left flank.
- Keep the fire from crossing the creek just south of the fire.
- Keep the fire from moving west into the rougher terrain and heavier fuels.

The Incident Commander instructs the remainder of the first alarm to follow him on the left flank. He feels that if this segment of the fire can be stopped, the threat to the structures can be eliminated. Dispatch is told to have the second alarm apparatus stage at the Canyon Creek "Y." By the time they arrive at staging, the situation will be clearer. By staging at the "Y," the units can either continue up the county road toward the Grady Ranch complex or head west on the county road, to take action as the fire approaches from the north (Figure 11.36).

A flanking action is used to protect the ranch buildings.

The right flank of the fire can wait until the ranch complex is no longer threatened and the head is stopped. The water tender will be moved closer to the origin to resupply the engines. In the meantime, the engines will have to move to the water source along the county road for water.

Suppression Strategy 2 - First priority is to protect the ranch complex.

As Engine 651 approaches the fire, the fire officer decides to take a defensive position to protect the Grady Ranch complex. He positions his engine to protect the various buildings and about 1,000 ton of bailed hay (Figure 11.37).

Incoming forces will by staged at the "Y."

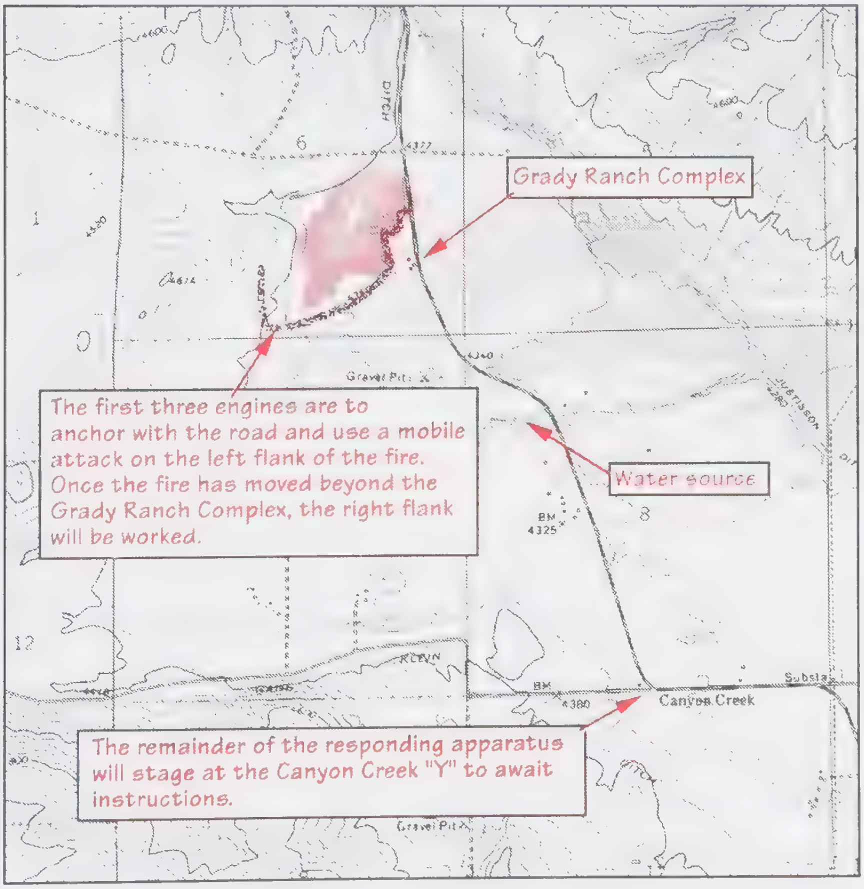
The objectives of this attack are:

- Protect the ranch complex.
- Keep the fire from moving east, threatening the ranch complex, or crossing the county road.
- Keep the fire from moving west into the rougher terrain.
- Keep the fire north of the creek.

The right flank can wait.

The second- and third-due engines are instructed to attack the left flank, working in tandem. They are told that a water

A water source has been identified.



Grady Ranch Complex

The first three engines are to anchor with the road and use a mobile attack on the left flank of the fire. Once the fire has moved beyond the Grady Ranch Complex, the right flank will be worked.

Water source

The remainder of the responding apparatus will stage at the Canyon Creek "Y" to await instructions.

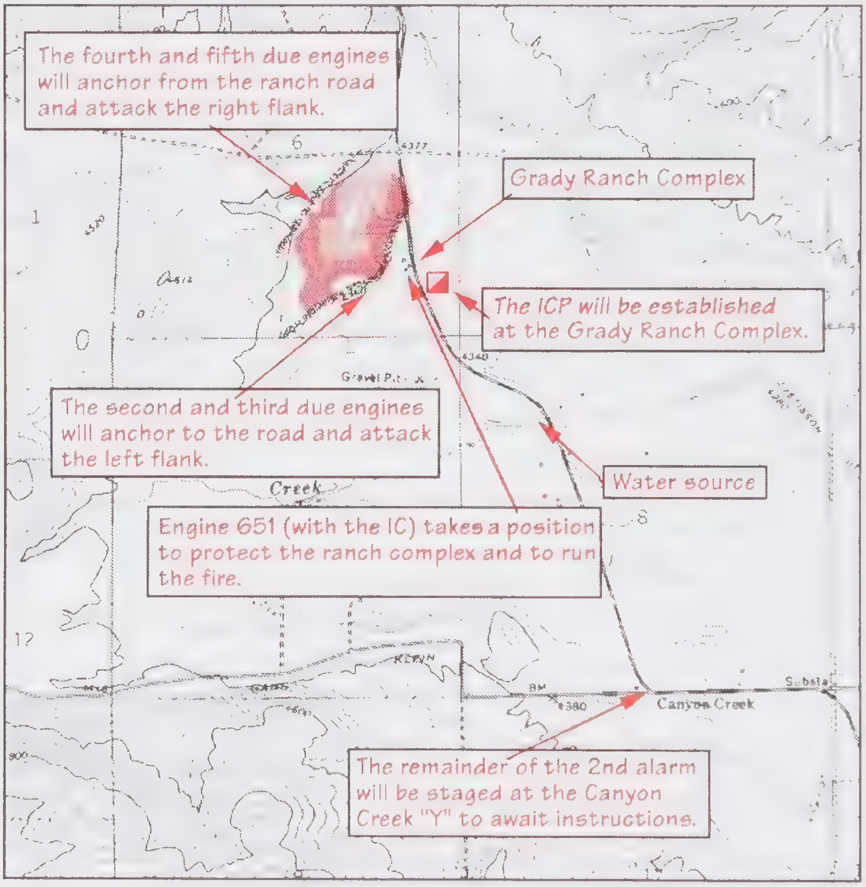
Figure 11.36 The strategy is simple. Attack the left flank, protecting the ranch complex and moving toward the head to cut it off. Once the primary spread is stopped, work the right flank.

supply is located just off the county road a mile south of the ranch complex.

The fourth-due engine of the first alarm and the first-due engine of the second alarm are told to attack the right flank, anchoring their attack at the ranch road. The remainder of the engines in the second alarm are instructed to report to the ICP at the Grady Ranch complex. They will be assigned as they arrive. The water tender is instructed to stage near the origin and to prepare to resupply the engines with water. The water tender operator is advised of the water source a mile south of the origin.

The IC briefs dispatch on the status of the fire and the general objectives. He asks for a spot weather forecast.

The first engine moves to protect the ranch complex.



The fourth and fifth due engines will anchor from the ranch road and attack the right flank.

Grady Ranch Complex

The ICP will be established at the Grady Ranch Complex.

The second and third due engines will anchor to the road and attack the left flank.

Water source

Engine 651 (with the IC) takes a position to protect the ranch complex and to run the fire.

The remainder of the 2nd alarm will be staged at the Canyon Creek "Y" to await instructions.

Figure 11.37 The Incident Commander positions his engine to protect the ranch complex. The next-due companies will be assigned to attack the flank. The priority will be the left flank.

Suppression Strategy 3 - Keep the fire from moving into the rougher terrain.

As Engine 651 approaches the fire, he sees that the fire is not yet a direct threat to the ranch complex. He is very concerned that the fire will move west into rough terrain and heavier fuels (Figure 11.38). With the limited firefighting personnel on each engine and the extended delay before the bulldozer arrives, the IC feels that it is critical to keep the fire from moving west. His plan is to attack the right flank, since he should have ample time before the fire moves too far east, threatening the ranch.

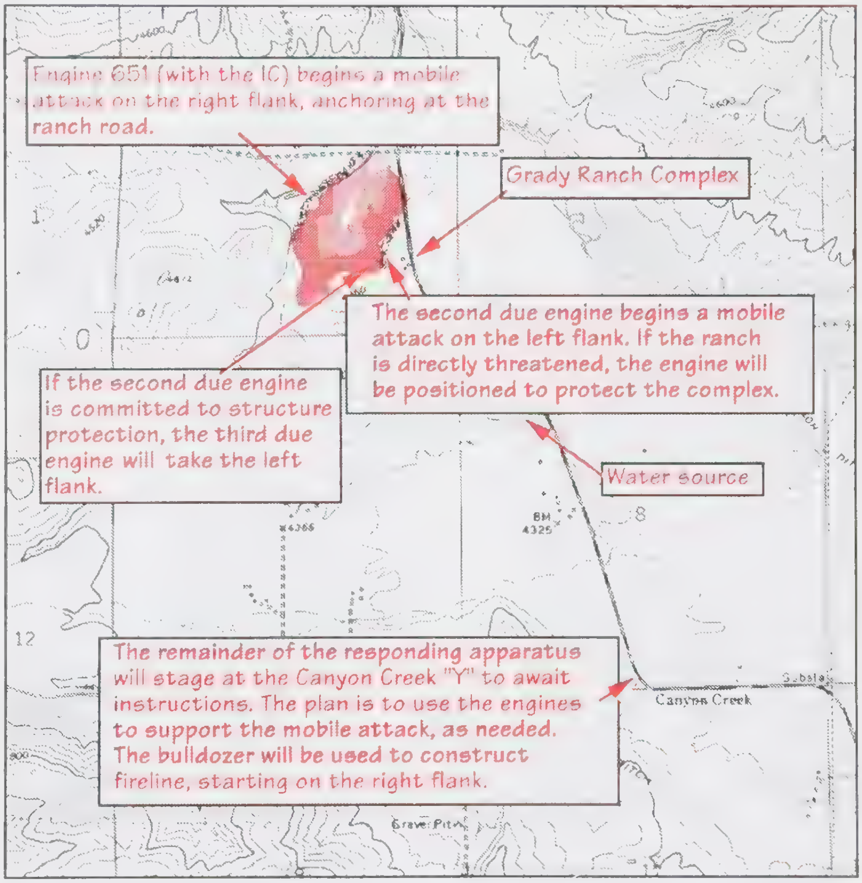
The plan is to keep the fire from moving into rougher terrain.

The IC's objectives are:

- Keep the fire from moving into the rough terrain and heavier fuels to the west.
- Protect the ranch complex.
- Keep the fire from moving east, threatening the ranch complex or crossing the county road.
- Keep the fire from crossing the creek to the south.

The second-due engine can check on the ranch complex.

The IC instructs the second-due engine to check out the ranch complex as he nears the fire. If there is still time before it is directly threatened, he is to attack the left flank, anchoring the fireline at the county road. The last engine of the first alarm will be used to protect the ranch complex or support the mobile attack on either the right or left flanks. The second-alarm assignment is to stage at the Canyon Creek "Y" to await instructions. More than likely, these resources will be used to back up the flanking



Engine 651 (with the IC) begins a mobile attack on the right flank, anchoring at the ranch road.

The second due engine begins a mobile attack on the left flank. If the ranch is directly threatened, the engine will be positioned to protect the complex.

If the second due engine is committed to structure protection, the third due engine will take the left flank.

The remainder of the responding apparatus will stage at the Canyon Creek "Y" to await instructions. The plan is to use the engines to support the mobile attack, as needed. The bulldozer will be used to construct fireline, starting on the right flank.

Figure 11.38 If time allows, the plan is to attack the right flank of the fire in an effort to keep it from moving into rougher terrain and heavier fuels. The remainder of the first-alarm assignment will protect the ranch complex and/or attack the left flank of the fire.

action. The water tender will be moved closer to the origin and will set up for resupplying the engines.

Firefighting Situation 7

You will be the first-due forestry fire officer. The fire is in heavy brush and moving upslope very quickly. It is in structures and is spotting.

It is 1430 hours, July 25th. You are the fire officer on a state forestry department engine. You are the most experienced company officer on the first alarm dispatched to a grass fire. The Battalion Chief is at least 45 minutes out.

The fire reportedly started from an illegal burn barrel. This area has experienced several fires during the last month. It is felt they are all tied to a feud between several of the local residents.

The fire has burned through grass and is into 50-year old, 12-foot tall brush on the side of the hill. The weather is in the 90s with the relative humidity at 16% (Figure 11.39).

The fire started on a Rancheria protected by a local fire district. This area is surrounded by private lands protected by state forestry. National forest land lies just off the map to the east. The fire has the potential for developing into a major incident that will cross several jurisdictional lines.

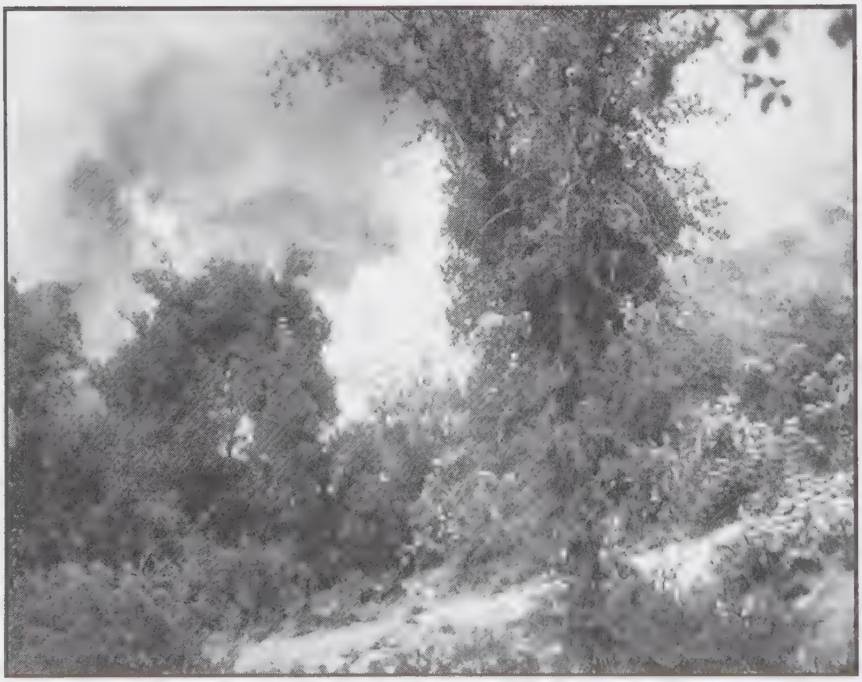


Figure 11.39 The fire is burning in heavy brush that hasn't burned in 50 years.

Situation: A lookout has reported a building smoke column just west of a state hospital. The lookout advises that the smoke had been white, but has now turned dark. Since it is a hot summer afternoon, a heavy wildland response has been dispatched. It includes five Type 3 engines with three firefighters on each engine, a bulldozer, water tender, and a Battalion Chief. The local fire district has also dispatched two engines with two firefighters on each engine. Since this area is a direct threat to a national forest, the Forest Service has dispatched a chief officer, three engines, an air attack, one helicopter, and two airtankers.

The first engine, which is from the fire district, arrives at scene 6 minutes after the dispatch and reports that the fire is moving up the slope at a moderate rate-of-spread. The engine captain advises that the fire is 10 acres and spotting. He states that they will be protecting the structures that are being threatened by fire in the grass. The engine captain on the first engine is designated "Rancheria IC" and is told what is responding. The second engine from the fire district arrives 3 minutes later and assists in the protection of the structures (Figure 11.40).

A second fire several miles to the north is reported.

You are still 8 to 10 minutes out when the lookout reports a second smoke column just north of the first one. The lookout states it is light in color, with little build. The dispatch office relays this information to the Incident Commander.

The Incident Commander is concerned about structure protection, as the four firefighters (on the two engines) are having difficulty protecting the structures they are assigned to. He asks dispatch to have all first alarm equipment respond to the point of origin. This information is relayed to all responding units.

You are about two miles from the first fire and can see it very clearly. It is moving in a northeasterly direction, up a steep, rocky slope. You can see that the fire is spotting. You can also see the second fire that was reported by the lookout (Point C). It is not a spot from the main fire, but a separate fire about a mile north on a separate ridge. You

Figure 11.40 The fire is directly threatening several structures. Quick action is required or they will be lost.

feel that if you divert to the new fire you will be able to control it before it can develop into a major problem.

You try to contact your dispatch office, but they are busy dispatching another fire. You cannot contact the Incident Commander. What do you do? Respond to the new fire, or continue in to the main fire?

Do you divert to the new fire or continue to the original one as instructed?

Following your primary instructions, you continue to the original fire. As you arrive at Point A, you see the fire moving up the ridge. You also see the fire backing down between several structures. The local fire district personnel have their hands full.

You position your engine to attack the fire threatening several structures (Figure 11.40). You contact your dispatch office and advise them you will be "taking over command of the fire," and will be placing an order for additional resources shortly.

"Rancheria Air Attack" is overhead and provides the following report on conditions:

Air attack is instructed to assist in the protection of the structures and to contain the second fire.

> *The fire is burning at a moderate rate-of-spread and spotting. It is over 50 acres and has crossed the ridge. There are at least two spots east of the main fire. The separate fire is a mile north of the main fire and has consumed a couple of acres of grass.*

The fire is moving into very steep terrain (Figure 11.41). The air attack officer also states that the jeep trail on the ridge above the fire (Points E - F) is not passable.

Solution Required: You are now the Incident Commander and responsible for the fire. The first Chief Officer will not be at scene for some time. Specifically you need to address the following issues:

- How will you organize the incident?
- What will your incident objectives be?
- What will you do about the second fire you saw on the way in?
- What additional resources will you order?
- How will you communicate with the other forces assigned to the fire?

This has the potential to be a major fire. How will you organize it?

Possible Solutions: Two possible solutions will be presented. They differ in how they will organize the fire, not in the priorities for controlling this potentially devastating fire.

Suppression Strategy 1 - Establish a two branch organization.

This fire has only been burning for thirty minutes, and it is already over 50 acres in size. The second fire (assumed to be a "set" fire) has to be given some priority or it will also become large very quickly. The following incident objectives are quickly set:

- Provide for immediate structural protection.
- Control the second fire.
- Keep the fire from crossing Mills Creek to the south.
- Keep the fire from crossing McClure creek to the north.
- Keep the fire from burning east as soon as possible.

The fire is divided into two branches.

The Incident Commander is convinced that this fire will not be controlled during the first burning period, thus "thinks big" right from the start. The organizational scheme is as follows:

- Establish a Unified Command, including representatives from state forestry, the fire district and the Forest Service.
- Divide the fire into two Branches—"Branch 1" will cover the main fire. It will be divided into two divisions. "Branch 2" will be responsible for the second fire.
- Form a Structure Protection Group to protect the structures in and near the Rancheria.

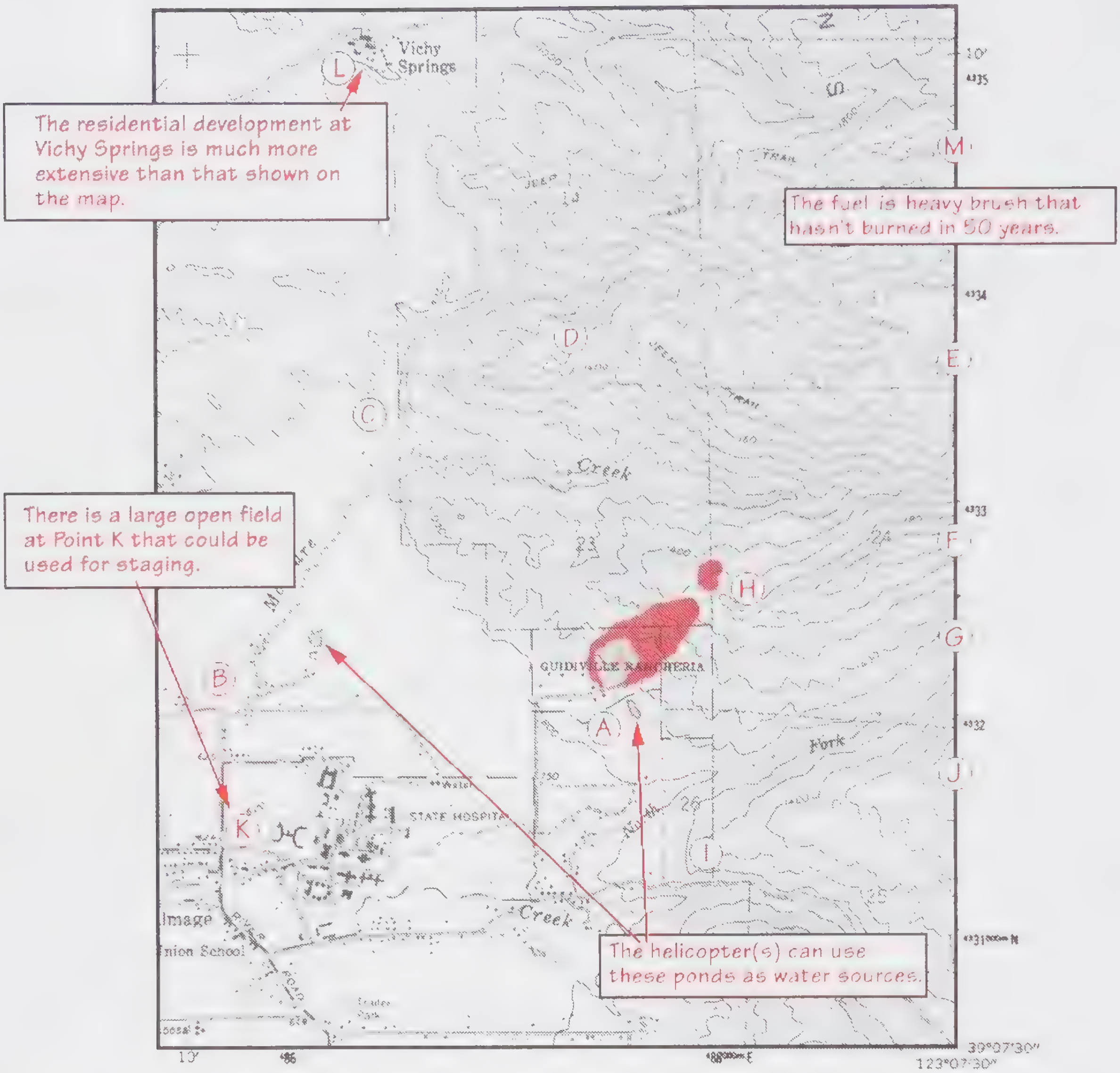
A structure protection group is formed.

The IC contacts dispatch, asks for a spot weather forecast, and places the following order for resources:

6 Type 3 Engine Strike Teams
2 Type 1 Engine Strike Teams
5 Type 2 bulldozers
6 Type 1 or 2 handcrews
2 Type 1 or 2 airtankers
1 Major Incident Management Team

A spot weather forecast is requested.

The general strategy places a priority on controlling the second fire. The helicopter (with crew), the next two engines, and airtanker support, will be assigned to the second fire. If this fire is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39°07'30"
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The residential development at Vichy Springs is much more extensive than that shown on the map.

The fuel is heavy brush that hasn't burned in 50 years.

There is a large open field at Point K that could be used for staging.

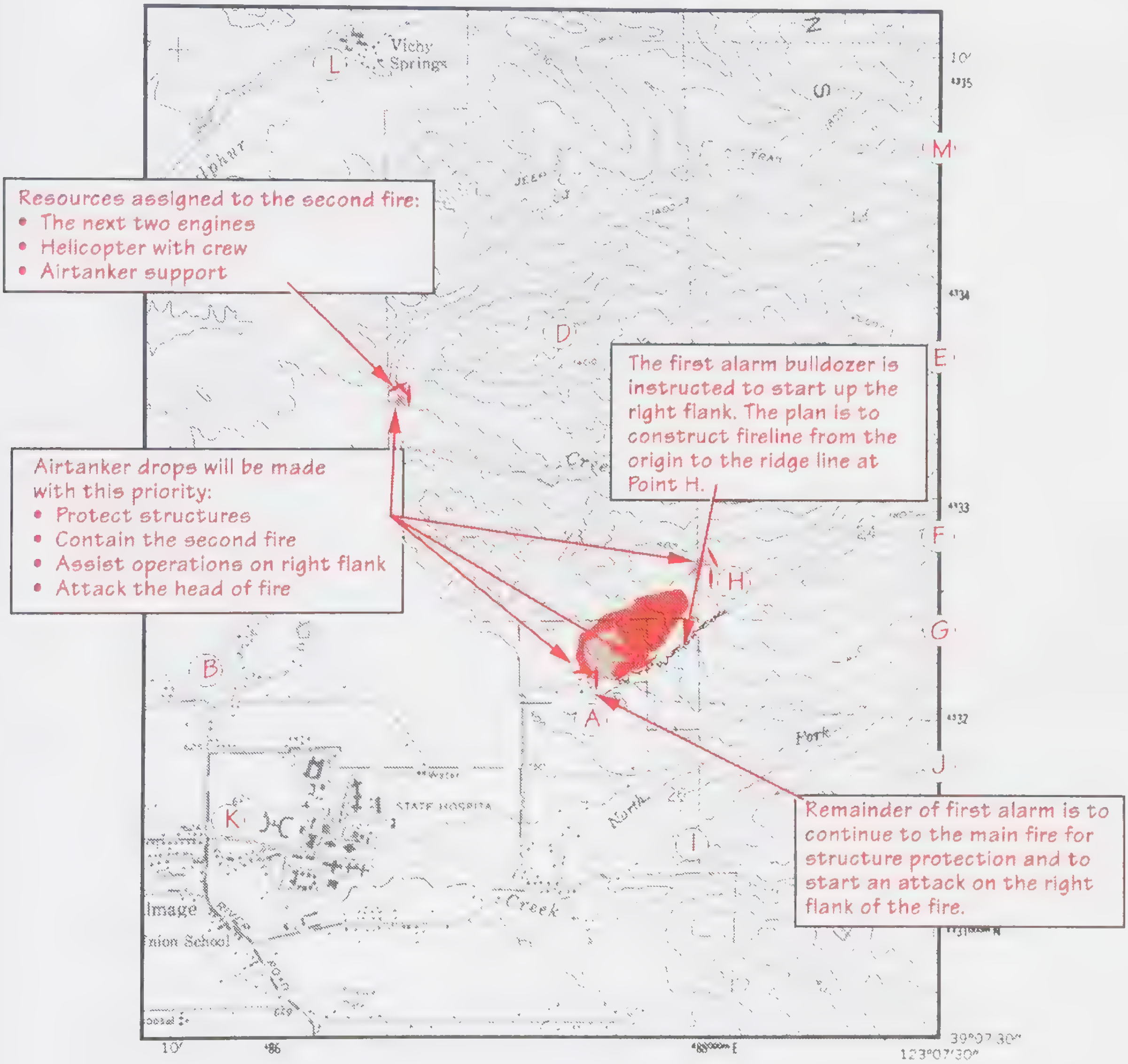
The helicopter(s) can use these ponds as water sources.

Figure 11.41 The fire has the potential to become a major incident. There are structures presently threatened near the origin. If quick action isn't taken, they will be lost. Several miles to the north, there is a large development at Vichy Springs. To the east, there are miles of brush, timber, and very broken and rough terrain.

not controlled quickly, the two fires will be allowed to burn together.

The remainder of the first alarm will be used to protect the threatened structures and to start construction of fireline along the right flank. The bulldozers will be used to construct direct line. If this isn't possible, they will be used to construct indirect line up the ridge toward Point H. This operation will be supported by ground forces with hose lays, and with airtanker drops. Once the second fire is controlled, the helicopter will be used to provide direct support on the right flank (Figure 11.42).

Radio communications will be a problem. Ensure that common radio frequencies are used as tactical nets. Cellular phones may be used for communications between command functions.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Resources assigned to the second fire:

- The next two engines
- Helicopter with crew
- Airtanker support

The first alarm bulldozer is instructed to start up the right flank. The plan is to construct fireline from the origin to the ridge line at Point H.

Airtanker drops will be made with this priority:

- Protect structures
- Contain the second fire
- Assist operations on right flank
- Attack the head of fire

Remainder of first alarm is to continue to the main fire for structure protection and to start an attack on the right flank of the fire.

Figure 11.42 The initial strategy is to protect the structures using the majority of the first-alarm assignment and airtanker drops. Two engines and the helicopter will be assigned to the second fire. Line construction will begin on the right flank of the main fire.

Suppression Strategy 2 - Establish a three-division organization.

A three-division fire organization is planned.

The Incident Commander meets with the fire officer for the fire district to see what structures are threatened. The IC positions his engine near a set of structures and has his crew set up to protect them.

The IC contacts "Rancheria Air Attack" and gives the following instructions;

> *Use airtanker drops to support the efforts to protect the structures near the origin of the fire. Assign the helicopter to take action on the second fire. Recon the second fire and report back as soon as you can.*

The IC establishes the following initial objectives:

- Protect the structures in the Rancheria.
- Attack the second fire.
- Begin control efforts on the right flank of the main fire.

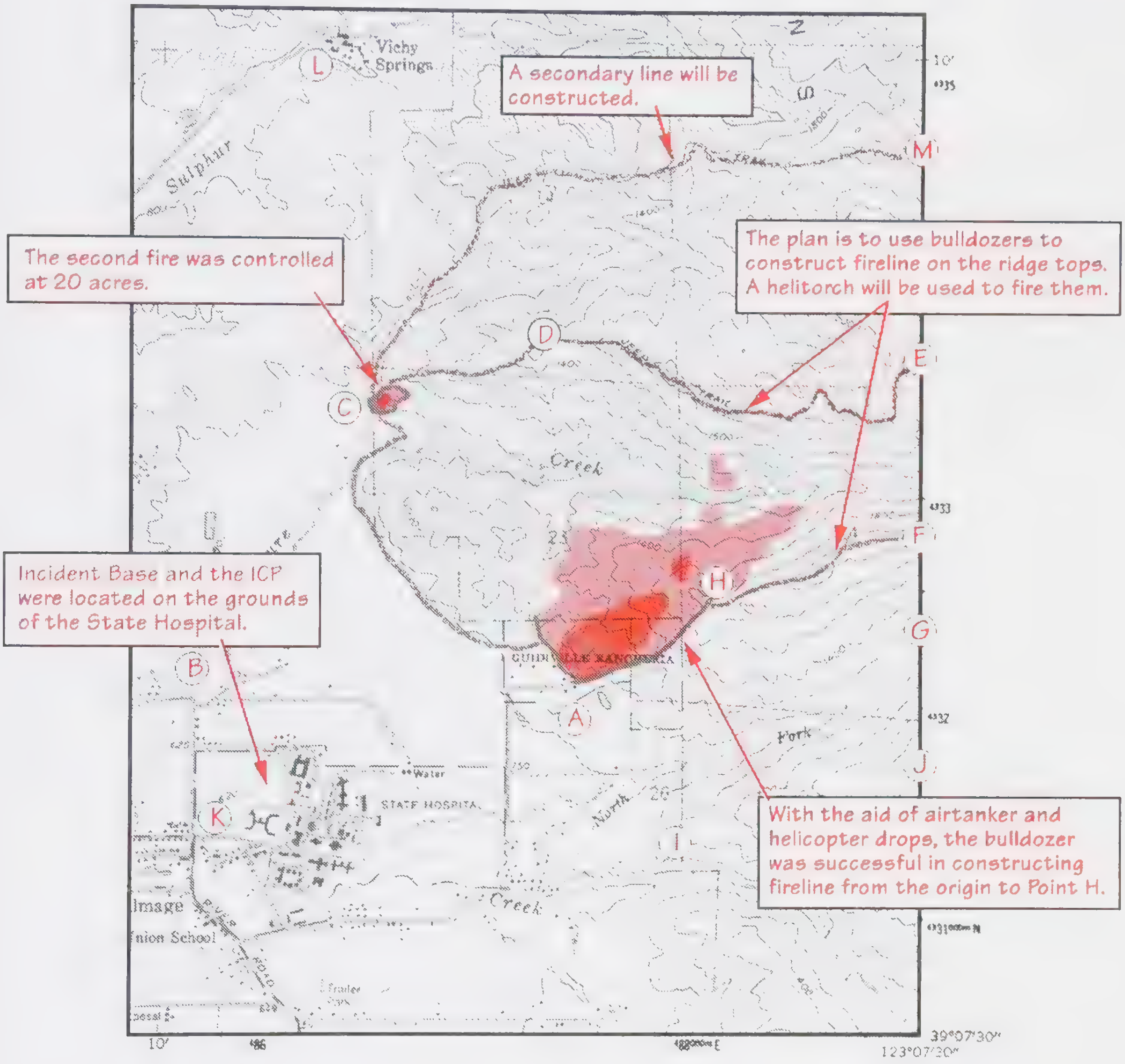
The IC is convinced he will not be able to catch the fire with the first alarm assignment. He orders for the long-haul.

The IC is convinced that this fire will be controlled not with a heavy commitment of engines, but with bulldozers, handcrews, and air attack. He places the following order for resources, knowing that he will need to place an additional order later in the day for command and logistic support:

3	Type 2 bulldozers
6	Type 1 handcrews
3	Division/Group Supervisors
2	Type 1or 2 airtankers
1	Type 2 helicopter, with bucket and crew

Until a chief officer arrives to take command of the incident, the fire officer must remain "detached" from his engine and command the incident. If control is lost, it will be difficult to pull it back together.

There is no question that this fire will become a major event. The weather, fuels, and terrain are all against you. It is early in a hot, dry summer day with the worst burning conditions still ahead of you. The fire is burning on a south and west facing slope, at the edge of a large valley that will develop up-canyon winds. It is imperative that the IC think big. One plan may be to use bulldozers to construct fireline on the ridges to the north and east of the fire, and use a helitorch to burn out the fireline (Figure 11.43).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A secondary line will be constructed.

The second fire was controlled at 20 acres.

The plan is to use bulldozers to construct fireline on the ridge tops. A helitorch will be used to fire them.

Incident Base and the ICP were located on the grounds of the State Hospital.

With the aid of airtanker and helicopter drops, the bulldozer was successful in constructing fireline from the origin to Point H.

Figure 11.43 It may be necessary to move well ahead of the fire with an indirect plan of attack. The terrain will probably not allow the use of a lot of engine companies. It appears this will be a bulldozer, airtanker, handcrew, and helicopter show.

Firefighting Situation 8

You have been assigned as the Operations Section Chief on a fire that is burning in steep terrain and is "running" toward several rural structures. The fire has been organized into four divisions (Figure 11.44). The fuels include timber and slash along the lower slopes, heavy chaparral brush on the mid-slopes, and grass (with many rocks) on the ridge.

The fire is moving out of the bottom of the canyon toward numerous structures on the ridge above.

It is a little after 1400 hours when you arrive at the fire; it has been burning for about an hour. You meet with the Incident Commander near the origin (Point A). She briefs you on the incident and, in addition to the map and sketch, provides a list of the equipment that is on the fire or on order. She also provides a brief weather report:

> *The present temperature, taken just minutes ago, is 94°, the relative humidity is 18%. The forecast indicates that a front will move into the area by midnight, bringing gusty winds. Tomorrow the temperatures will drop by 10° and the relative humidity will increase by 20%.*

You move to the ridge to develop your plan.

The Incident Commander outlines the incident objectives:

- Protect the structures on the ridge line.
- Hold the fire west of Highway 32.
- Keep the fire east of Chico Creek.
- Keep the fire from moving up-canyon.
- Cut off the fire in a convenient location as it moves south.

The Incident Commander tells you that it will take about 30 minutes to drive from the origin to Point D on the highway. There is no way to move engines or bulldozers across the creek.

Situation: You have been briefed on the fire and have about 20 minutes to come up with your plan of attack. Some of your resources will not arrive until later in the afternoon. Two of the Division/Group Supervisors will not arrive until after dark.

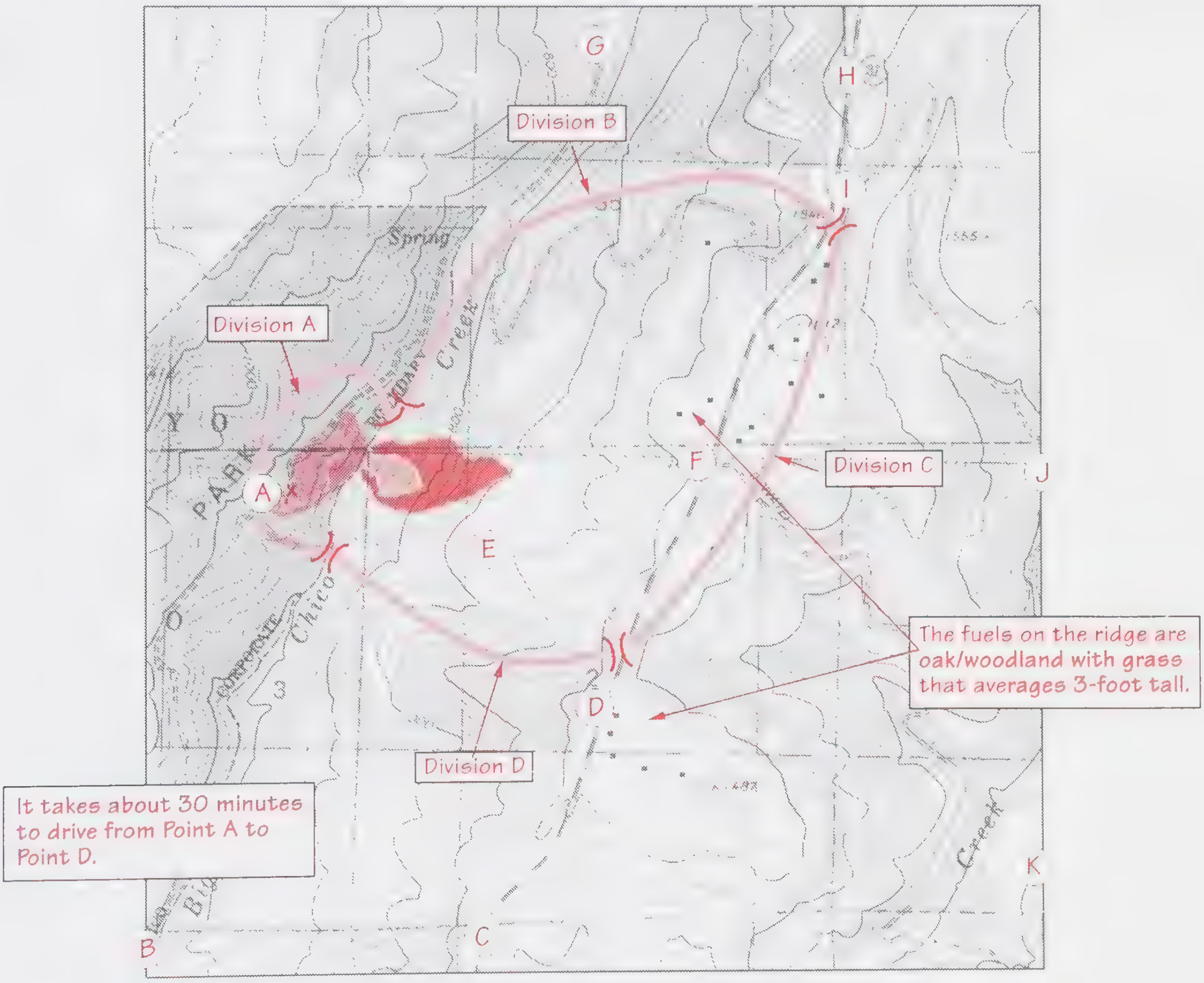
The fire is contained west of the creek (Division A). Three city engines have this area well in hand. Two state forestry engine companies, backed up by two Type 1 handcrews, are constructing a wet line and hand line up the left flank of the fire in Division B.

This is a slow process because it is steep terrain, with numerous rock outcroppings and cliffs. Water is not a problem near the creek; however, it will be a problem on the ridge.

You meet with Division A, the city Battalion Chief. He tells you that he has about 20 acres of fire in the city on the east side of the creek (the creek is the city/county line). He states he can handle this section with the units he has, but it would be helpful if he could get a handcrew to construct fireline. If that isn't possible, he will use wet line.

You meet with Division A. That part of the fire is contained.

Division B, the captain assigned to one of the state forestry engines, tells you he is making very slow progress constructing



The fuels on the ridge are oak/woodland with grass that averages 3-foot tall.

It takes about 30 minutes to drive from Point A to Point D.

Figure 11.44 The Incident Commander has given you a topographic map of the fire and a sketch of the initial organization arrangement.

fireline. The steep, rocky terrain is very difficult to work on. He feels that it will be difficult to construct direct line all the way to the top from the creek. If that is the plan, then he will need two more engines, three handcrews, and 2,000 feet of hose, and assorted adapters and nozzles.

If you plan on an extended hose lay, Division B is going to need a lot of hose and some help.

You call Division C on the cellular phone to discuss the situation on the ridge. The division is presently staffed with a strike team of Type 2 engines from the county. The Strike Team Leader is functioning as Division C. You are told that they have taken up a position along the highway, but there is currently no action. There is some smoke and light ash, but no spotting. It is 96° with a relative humidity of 18%. The winds are out of the west, southwest at about 10 miles per hour. Division C asks what the plan is. You tell him you are working on it. Division C says that if the fire hits the ridge, he will need another strike team of engines for structural protection.

Division C wants to know what the plan is.

You review the resource list (Figure 11.45). It is your gut feeling that the fire will run to the ridge in the next several hours and that the resources committed to the incident are less than what is really needed. You are suspicious of the weather forecast; it does not match the local weather.

The list of resources on the fire or en route is as follows:

Forces at scene:

1 City Battalion Chief (Division A)
3 City Type 1 engines (assigned to Division A)
1 State Forestry Battalion Chief (the Incident Commander)
4 Type 3 state forestry engines
2 Type 1 handcrews (Division B)
1 Type 2 state forestry bulldozer (on the ridge with Division C)
1 Type 2 county Engine Strike Team (Division C)

The forces en route:

2 Type 2 bulldozers
1 Type 3 Engine Strike Team
1 Type 1 or 2 Engine Strike Team
3 Division/Group Supervisors (you are one of them)
4 Type 1 or 2 handcrews

Figure 11.45 The list of resources committed to the incident.

Solution Required: You are to develop a plan that will meet the objectives presented to you using the resources committed to the fire. Specifically:

- How will you allocate the resources to the various divisions?
- Where will you position yourself? Where do you recommend the ICP be located?
- Where will you stage the incoming resources?
- What will be the tactics used on each of the divisions?

Where will you recommend the ICP be located?

Possible Solutions: Two possible solutions to this situation will be presented. The first plan is to construct extensive indirect line and to burn it out. The second is a little more conservative. It involves a direct attack from the creek, using an indirect attack only to keep the fire from crossing the highway.

Suppression Strategy 1 - An indirect attack.

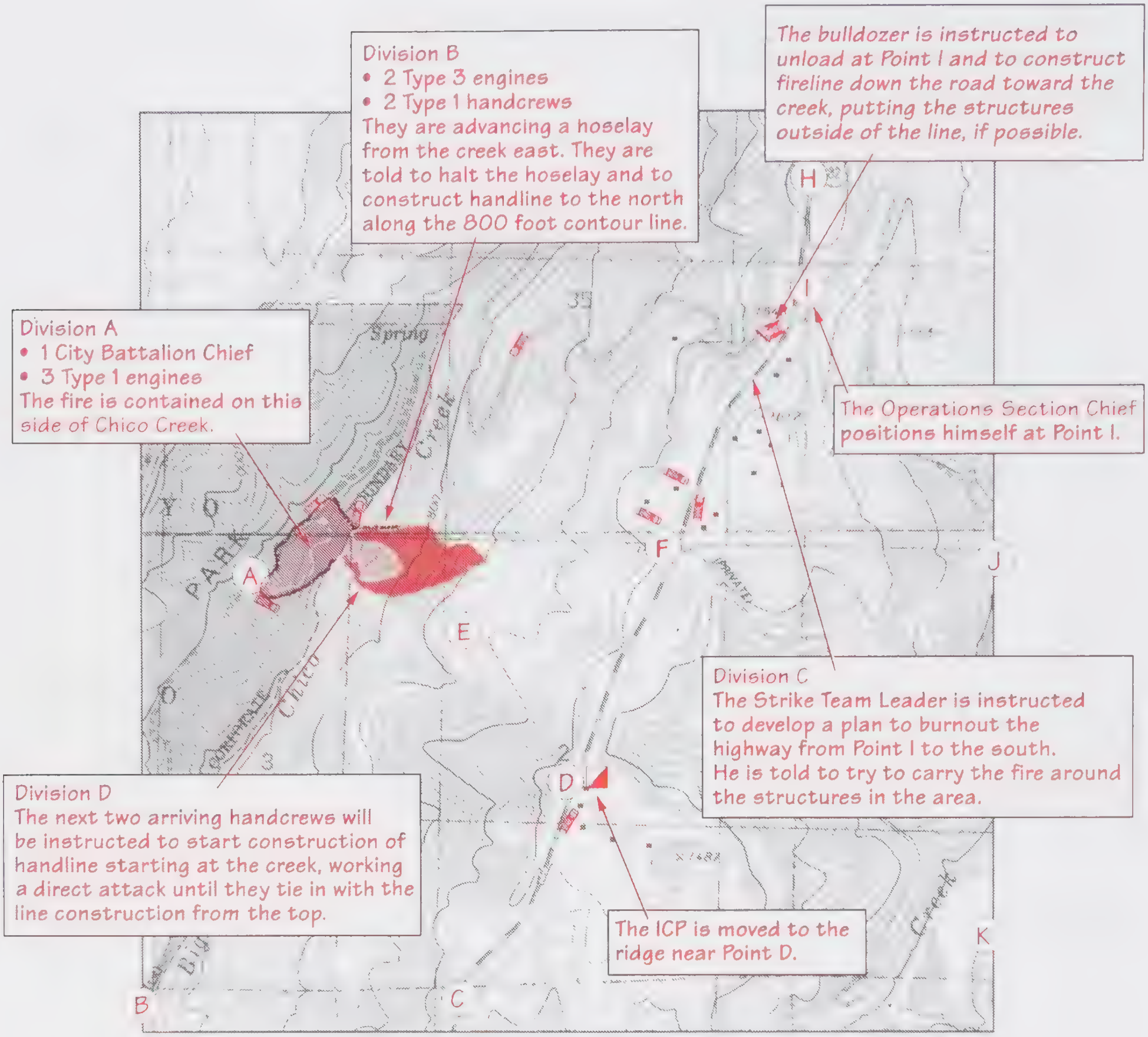
Since most of the action is going to occur along the highway above the fire, the Operations Section Chief moves to Point F. En route, he looks over the terrain and fuels, and looks for a good spot to stage the incoming resources. Based on what he has heard from Division B, he feels that it is necessary to use an indirect attack on that division. He develops his plan and briefs the IC on it (Figure 11.46).

An indirect attack plan is developed.

The Operations Section Chief contacts Division B and gives him the following instructions: Stop the hose lay at about the 800-foot contour line. Use the handcrews to reinforce the existing wet line. Start constructing hand line toward the north and tie in with the bulldozer that will be heading down the ridge (road) toward you. The bulldozer and two additional Type 3 engines are assigned to Division B. The two engines will begin firing from Point I as soon as the bulldozer has constructed fireline beyond the cabin.

The bulldozer will construct fireline on the north flank of the fire.

The Operations Section Chief then contacts Division C. He tells the Battalion Chief that he is to gather his forces near Point I and to get prepared to begin firing the highway from Point I downhill toward Points F and D. He is to carry the fire around the two structures near Point F, if he can.



Division B
- 2 Type 3 engines
- 2 Type 1 handcrews

They are advancing a hoselay from the creek east. They are told to halt the hoselay and to construct handline to the north along the 800 foot contour line.

The bulldozer is instructed to unload at Point I and to construct fireline down the road toward the creek, putting the structures outside of the line, if possible.

Division A
- 1 City Battalion Chief
- 3 Type 1 engines

The fire is contained on this side of Chico Creek.

The Operations Section Chief positions himself at Point I.

Division C
The Strike Team Leader is instructed to develop a plan to burnout the highway from Point I to the south. He is told to try to carry the fire around the structures in the area.

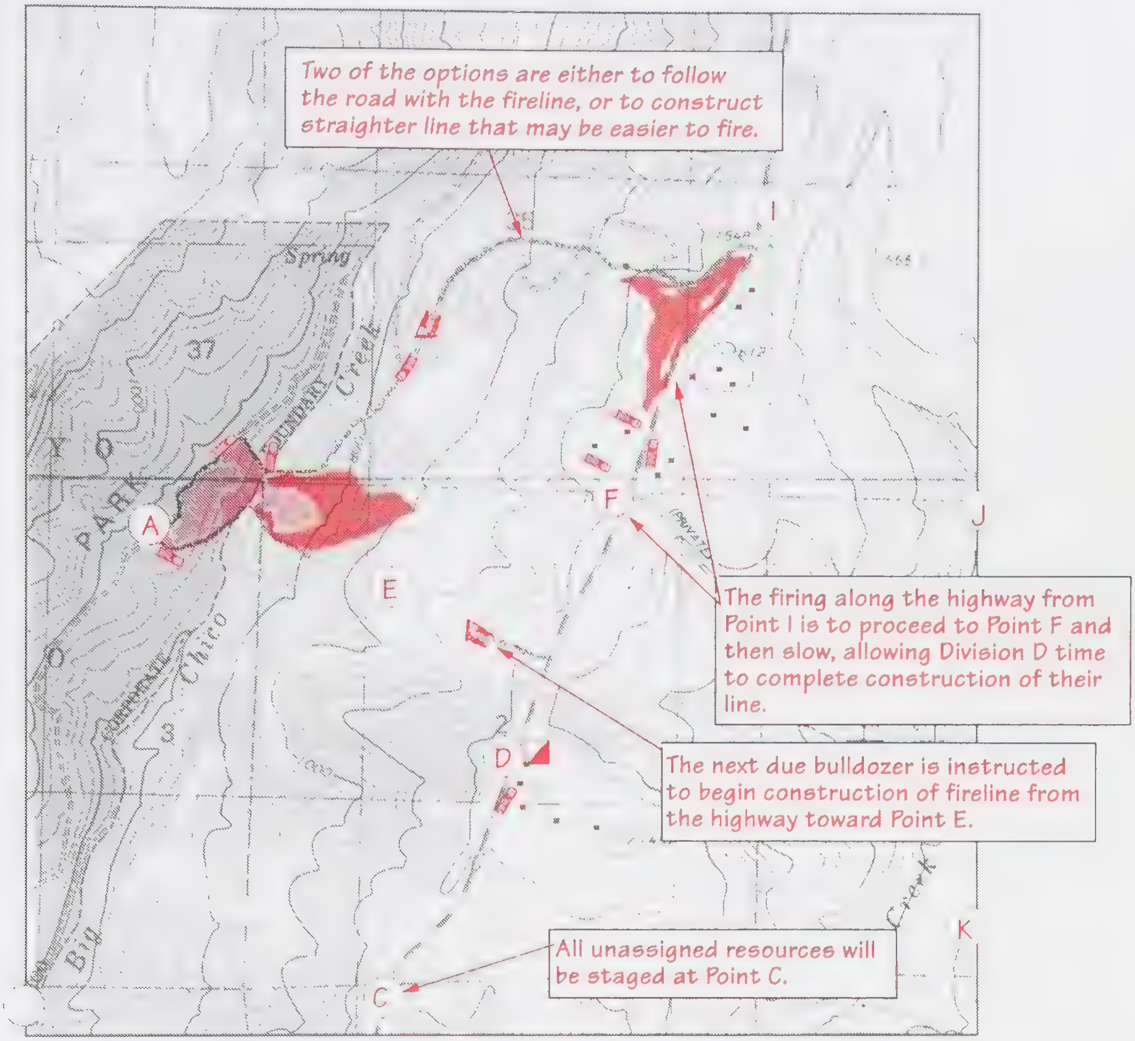
Division D
The next two arriving handcrews will be instructed to start construction of handline starting at the creek, working a direct attack until they tie in with the line construction from the top.

The ICP is moved to the ridge near Point D.

Figure 11.46 The plan is to use indirect line and a firing operation on Division B. The forces on Division C will fire the highway, coordinating the firing operations with Division B. Division D will involve a more direct attack at the bottom to an indirect attack from above. Once the lines on Division D are tied together, they will be fired from Point D, working toward Point A.

Division D will be staffed last.

Division D is not yet staffed. The next two handcrews will be told to move to Point A and to begin construction of hand line from the creek up the right flank of the fire. The next-due bulldozer will be told to unload between Points F and D and prepare to construct line from the highway west toward Point E (Figure 11.47).



Two of the options are either to follow the road with the fireline, or to construct straighter line that may be easier to fire.

The firing along the highway from Point I is to proceed to Point F and then slow, allowing Division D time to complete construction of their line.

The next due bulldozer is instructed to begin construction of fireline from the highway toward Point E.

All unassigned resources will be staged at Point C.

Figure 11.47 The firing operations on Division B have to be tied in with the firing on Division C. They must be well coordinated or there will be a major problem on that corner of the fire. The firing will have to move slowly.

The Operations Section Chief suggests to the Incident Commander that she move to Point D on the ridge and that all incoming resources be instructed to report to a staging area at Point C. The Operations Section Chief also requests that a Staging Area Manager be ordered.

A direct attack plan is developed.

Suppression Strategy 2 - A direct attack.

The Operations Section Chief is very concerned. He doesn't want any more fire than necessary, so he is not going to do a lot of indirect attack. He feels the fire will continue in a northeasterly direction and be slowed by the rocks and bluff. As he moves to the ridge near Point D, he can see a spur ridge off to the left (Point E) that may be used as a potential location for the fireline. He meets with Division C, who has just driven down to Chico Creek using the road which leaves the highway at Point I. He says that Type 3 engines can use this road.

The highway will be fired just enough to keep the main fire from crossing it.

The Operations Section Chief then contacts the IC on the cellular phone and briefs her on the plan. He plans on moving the bulldozer and two Type 3 engines down the road from Point I to a point just above the creek. The bulldozer will then move south along the 800-foot contour line, constructing fireline and access for the engines. When the bulldozer reaches the fire, it will tie in with the wet/hand line being constructed by Division B. The next two handcrews will also be assigned to Division B. This force is then to continue a direct attack east along the fire's edge.

The bulldozer leads engines into the flank of the fire.

Division C is to use limited firing along the highway to keep the main fire from crossing it. This indirect attack will be turned back toward the advancing lines from below (See Figure 11.48). The next-due bulldozer will assist in this action.

The last two handcrews will be assigned to Division D to start construction of line from the creek toward Point E. As soon as this line is tied in with the line being constructed from above, these two crews, with the aid of several engine companies, will fire it out.

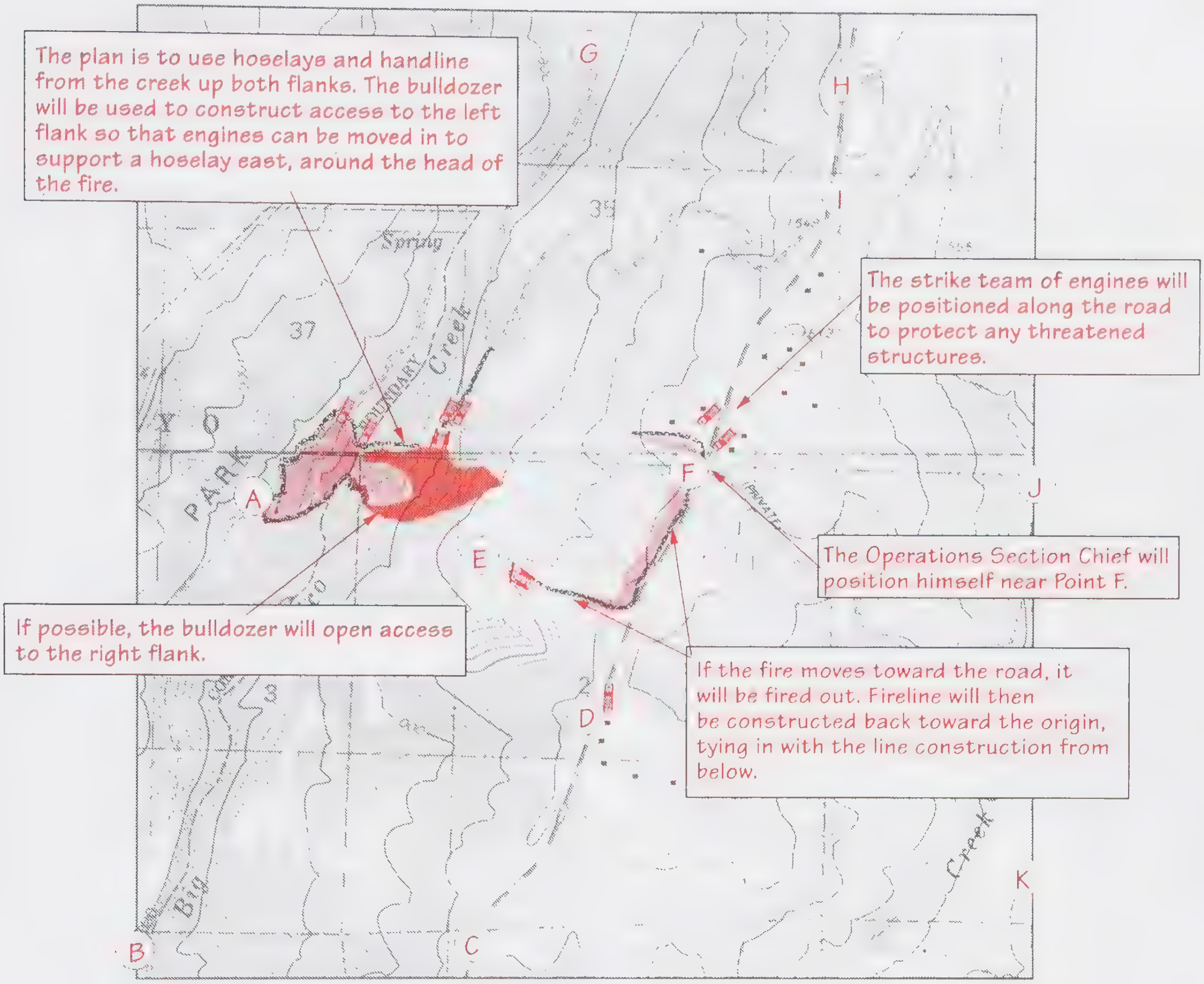
The ICP is moved to the ridge.

The Operations Section Chief suggests that the IC move the ICP to somewhere along the highway and that a Staging Area be established at Point D.

Firefighting Situation 9

You are the engine captain on one of three engines operated by a rural fire district. All of the engines are staffed with two firefighters. Mutual aid is available from other fire districts.

It is late September and the leaves are turning and falling. The area you protect is rural foothills, with a mix of grass and brush with scattered oaks and other hardwoods. The winds are generally out of the west or southwest.



The plan is to use hoselays and handline from the creek up both flanks. The bulldozer will be used to construct access to the left flank so that engines can be moved in to support a hoselay east, around the head of the fire.

The strike team of engines will be positioned along the road to protect any threatened structures.

The Operations Section Chief will position himself near Point F.

If possible, the bulldozer will open access to the right flank.

If the fire moves toward the road, it will be fired out. Fireline will then be constructed back toward the origin, tying in with the line construction from below.

Figure 11.48 The plan is to burn only what is necessary to keep the fire from crossing the highway.

The last several days have been warm and dry. The local weather forecast indicates that the temperature will be in the high 80s today, with humidities in the 20s. The wind will be out of the west at 10 to 15 miles per hour, with gusts to 20 miles per hour. You have already been to two grass fires and one medical aid call today.

You are part of a three-engine dispatch. You see the smoke from some distance.

Situation: At 1436 hours, you are dispatched to a grass fire that is reportedly threatening several structures near 4100 Marble Ridge Road. The fire is in your first-in district, but it will take you about 12 minutes to get there. All three of the district engines are dispatched. The chief will not be available for an hour. You are the first-in engine and you assume command of the incident.

You approach the fire via the freeway, from the east. As you take the off-ramp you see that the fire is on the ridge; you cannot see how much fire is on the other side of the hill. You turn on Marble Ridge Road (Point B) and proceed to the reporting party's address, which is the first driveway on the right. As you top the ridge, you see that the fire is near several outbuildings and has spotted across the road about 200 yards ahead of you (Figure 11.49).

The fire has spotted across the road.

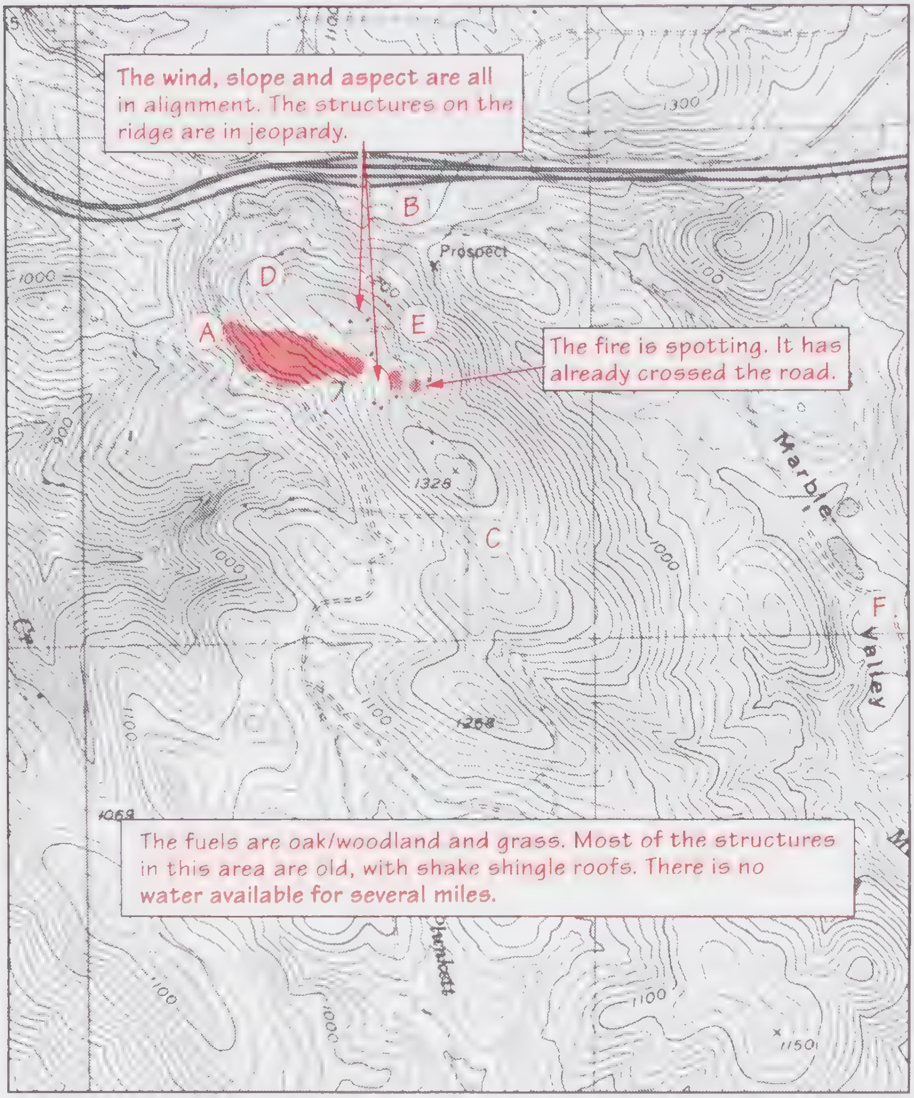

The wind, slope and aspect are all in alignment. The structures on the ridge are in jeopardy.
1300
B
Prospect
1000
D
A
E
The fire is spotting. It has already crossed the road.
Marble
1328
C
900
1000
F
Valley
1100
1268
1068
The fuels are oak/woodland and grass. Most of the structures in this area are old, with shake shingle roofs. There is no water available for several miles.
1150

Figure 11.49 As you arrive, you see that the fire is moving toward several structures and has crossed Marble Ridge Road.

Solution Required: It will be some time before you get any help. As the Incident Commander, what will your actions be? Specifically:

- What will your report on conditions be?
- What will your priorities be? Will you protect the structures or attempt to control the fire west of Marble Ridge Road? What about the spot fire?
- How will you assign the next two engines?
- If you order additional equipment, what will you order?

Possible Solutions: Two potential solutions will be given for this problem. This is a common event, where the fire officer has to choose between attacking the fire to prevent further threats to exposures, or protecting the exposures and dealing with a larger wildland fire when more resources arrive. There is also the problem of locating all of the structures that may be threatened. In this case, there is one that is well hidden from the responding companies.

You are not sure you know where all the structures are located.

Suppression Strategy 1 - Protect the exposed structures and recon the area.

As the first-in officer arrives at scene, he assesses the situation and gives the following report on conditions:

> *Grass fire 20-30 acres; has crested the ridge west of Marble Ridge Road; origin is on the west side of the ridge; unable to see the whole fire from my location. Several structures threatened on the west side of the ridge at this time. Will be moving to protect them. Stand by for a request for more equipment. I'll be "Marble IC."*

You have 20 to 30 acres of grass on fire and structures are being threatened.

In your mind you outline the initial action objectives:

- Provide the best structure protection possible.
- Gather intelligence on the fire situation and the location of the structures.
- Begin perimeter control.

You mentally review the fire behavior and potential. The fire was burning on a west-facing slope, nearing its peak fuel temperatures. The wind is from the west and the fire is burning upslope. Once the fire crosses the ridge, conditions (such as slope and aspect) change, and the fire will slow. You also know there are no exposures to the east for a mile or so.

The wind, slope, and aspect are all in alignment.

You contact the two remaining engines of the first alarm and give them their assignments. You tell them you have positioned your engine to protect the structures at 4100 Marble Ridge Road. Engine 2 is to move beyond the head of the fire and protect the structures south of Engine 1. Engine 3 is to follow Engine 2 past the head of the fire and recon the area, locating all the structures that might be threatened. Engine 3 is then to report back to the IC on what is found (Figure 11.50).

The first engine takes the first threatened structure found.

Marble IC then contacts dispatch and places the following order for resources:

The IC orders more resources.

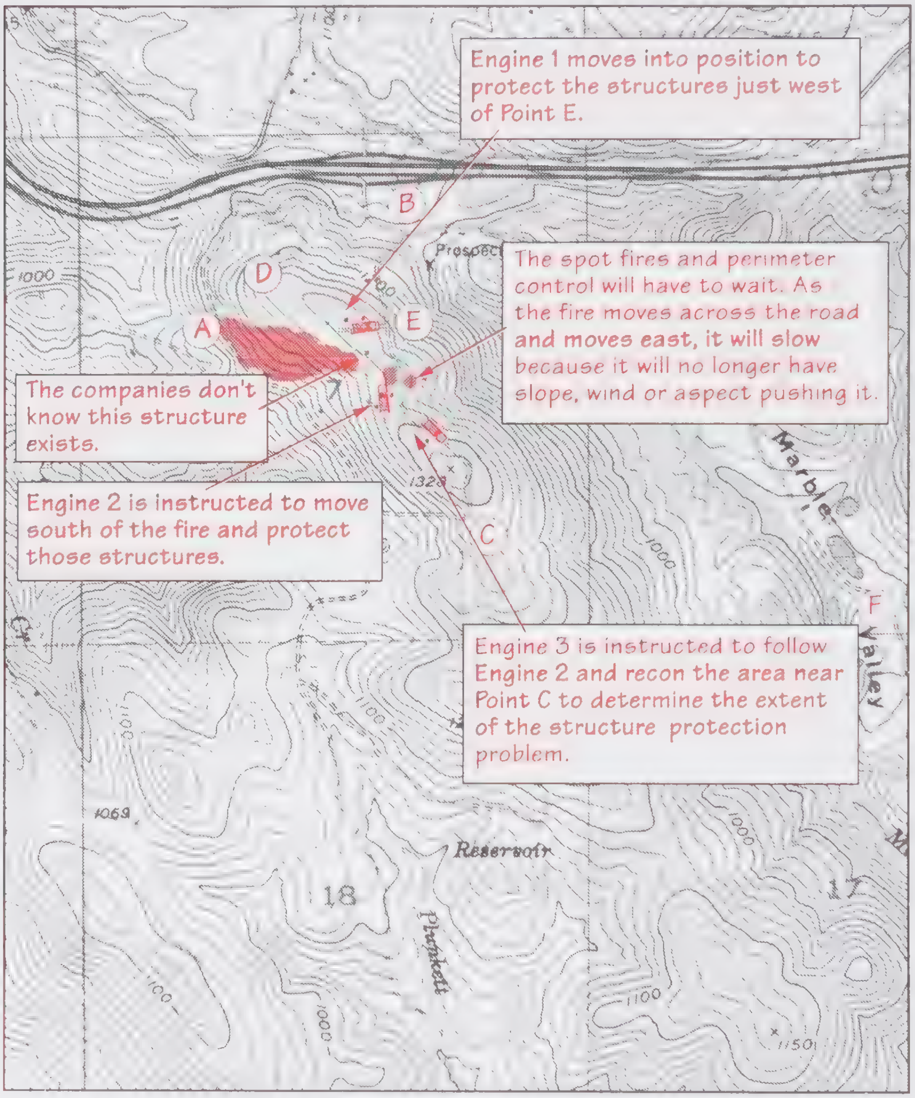
3 Type 1 or 2 engines (closest and immediate)
4 Type 3 engines (closest and immediate)
1 Type 2 or 3 bulldozer
2 Water tenders

The IC asks if any aircraft are available. He is told no.

These resources are to respond to the Bass Lake off-ramp to Highway 50 and report in to the IC from there. Dispatch is told

The second engine is told to move south of the fire and to protect structures.

The third engine is told to recon the situation.



Engine 1 moves into position to protect the structures just west of Point E.

The spot fires and perimeter control will have to wait. As the fire moves across the road and moves east, it will slow because it will no longer have slope, wind or aspect pushing it.

The companies don't know this structure exists.

Engine 2 is instructed to move south of the fire and protect those structures.

Engine 3 is instructed to follow Engine 2 and recon the area near Point C to determine the extent of the structure protection problem.

Figure 11.50 The first-in engine takes a position to protect the structures on the knob above the fire. The IC instructs the next two engines to go south of the fire and protect any structures that are threatened. Perimeter control will have to wait.

that the first alarm is in a defensive mode, protecting structures. They are also told the fire has crossed Marble Ridge Road and is moving east.

The plan is to use the Type 1 or 2 engines for structure protection. The Type 3 engines and the bulldozer will concentrate on perimeter control. The water tenders will be used to provide water for the whole operation.

The Type 3 engines will be used to control the perimeter of the fire.

Suppression Strategy 2 - Protect the exposed structures and start perimeter control.

As Engine 1 crests the hill near the head of the fire, the fire officer sees that the fire has spotted across Marble Ridge Road and is moving toward the valley below. He feels it will slow as it moves onto the east-facing slope. As the engine nears the reporting party's address, the fire officer sees that the structures are not in immediate danger and elects to move past the head of the fire to see what exposures exist on the south side of the fire. Engine 1 positions itself to protect several structures south of the fire. The fire officer on Engine 1 gives the following report on conditions to dispatch:

Not all of the first alarm is committed to structure protection.

> *Engine 1 on scene of a grass fire moving uphill with the wind at a moderate rate-of-spread. Fire is spotting and threatening structures. Engine 1 is assuming Marble IC. Request a second alarm consisting of two Type 2 or 3 Engine Strike Teams and two Type 1 or 2 handcrews. All immediate need, and closest if possible.*

The Incident Commander establishes the following objectives:

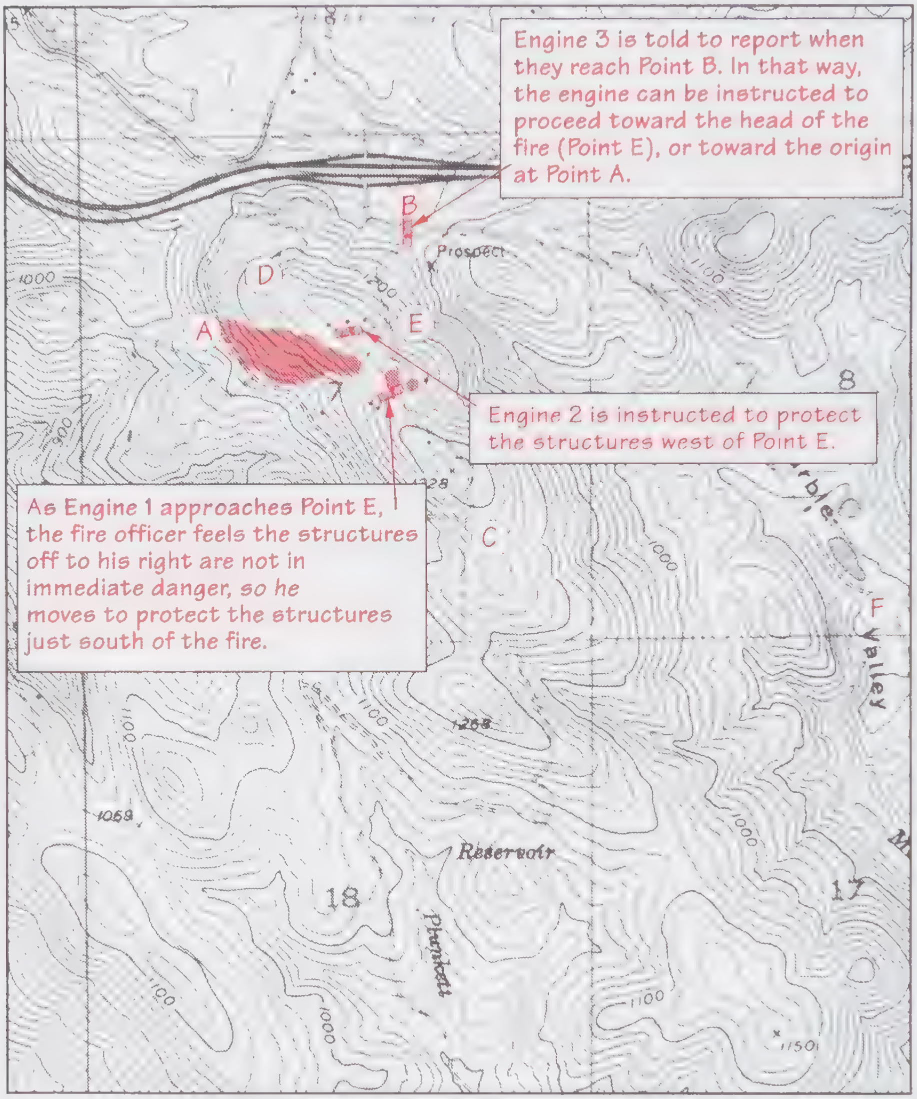
- Provide structure protection to homes on the ridge.
- Attack the perimeter when resources become available.

The protection of the structures is still the top priority, but perimeter control is still important.

Marble IC contacts Engine 2 and tells the fire officer to proceed to 4100 Marble Ridge Road and to protect those structures. Engine 3 is told to check in before committing to Marble Ridge Road. Depending on the situation when Engine 3 checks in, they could be directed to proceed up the road to the head of the fire, to the east out ahead of the fire, or to the west to the origin. If conditions allow, Engine 3 will be instructed to proceed to the origin of the fire to begin a flanking attack on the left flank (Figure 11.51).

The first several engines of the second alarm will be instructed to attack the fire east of Marble Ridge Road.

The first elements of the second alarm will attack the spot fire.



Engine 3 is told to report when they reach Point B. In that way, the engine can be instructed to proceed toward the head of the fire (Point E), or toward the origin at Point A.

Engine 2 is instructed to protect the structures west of Point E.

As Engine 1 approaches Point E, the fire officer feels the structures off to his right are not in immediate danger, so he moves to protect the structures just south of the fire.

Figure 11.51 The first-in engine company moves south of the head of the fire and takes up structural protection there. The second-due company is to protect the structures north of the fire's left flank. The third engine company can be used to protect additional structures, attack the spot fire, or start a flanking action from the origin.

Firefighting Situation 10

You are the Fire Management Officer of a national forest in the Sierras of California. You have just returned from a team assignment in Colorado. The weather has been hot—day-time temperatures have been over 100° the last several days. There are several large fires burning throughout the area. You know if you break a new fire, firefighting resources will be limited.

It is a hot summer day, when an arsonist sets five fires.

As you are having coffee in the morning, you check the fire weather forecast:

```
     NATIONAL WEATHER SERVICE
     FIRE WEATHER FORECAST
     300 PM PDT TUESDAY AUGUST 12

     DISCUSSION: THE UPPER LEVEL HIGH OVER THE AREA
WILL CONTINUE TO BRING VERY HOT AND DRY WEATHER FOR
THE NEXT SEVERAL DAYS.

     TONIGHT. . .
       WEATHER: THE NIGHT WILL BE CLEAR.
       LAL: 3. THERE WILL BE LIMITED AFTERNOON
       EVENING THUNDERSTORMS. THEY WILL END AFTER
       DARK
       TEMP/RH: TEMPERATURES WILL REMAIN UNUSUALLY
       WARM, IN THE MID 70S WITH VERY LITTLE RH
       RECOVERY.
       WIND: SOUTHWEST TO WEST 5 TO 8 MPH

     WEDNESDAY. . .
       WEATHER: VERY HOT AND DRY.
       LAL: 1
       TEMP/RH: HIGH TEMPERATURES ABOVE 100°.MINIMUM
       HUMIDITY 8 - 14%.
       WIND: UPCANYON/SLOPE WINDS 8 - 12 MPH IN THE
       AFTERNOON. EVENING DOWNSLOPE WINDS WILL
       REACH 7 MPH AFTER DARK.

     THURSDAY. . .
       CONTINUED HOT AND DRY.
```

The weather forecast is for continued hot and dry weather.

Situation: At 0925 hours, the forest dispatch office receives a call from the caretaker at Bower Cave Resort reporting several fires up the road. The dispatcher checks with Pilot Peak Lookout; the lookout doesn't see anything, but adds that he is blind in that direction. The Kinsely Station Patrol and a Type 3 engine from McDiarmid Station are dispatched. You also begin your response; it will take you over an hour to get there.

The lookout finally can see the fire.

At 0929 hours, the Pilot Peak Lookout reports he can now see smoke coming up over the ridge. It is a "building" dark smoke.

At 0945 hours, the Kinsely Patrol arrives and gives the following report on conditions:

Airtankers will not be available.

> *We have several fires burning above Coulterville Road at Briceburg Road....moderate rate-of-spread, in heavy brush. Combined, they are about 10 acres in size. Request a strike team of engines, two bulldozers, aircraft, and three handcrews.*

The dispatcher acknowledges the report and the request for additional assistance. He says he will get what he can. Airtankers are not available, but he may be able to get a helicopter and an air attack aircraft.

The fuels are ponderosa pine and black oak with a heavy ground cover of manzanita and scrub oak. Elevations range from 2,350 feet at the origin to about 3,400 feet on the ridges. There has been a problem with arson in the area for years.

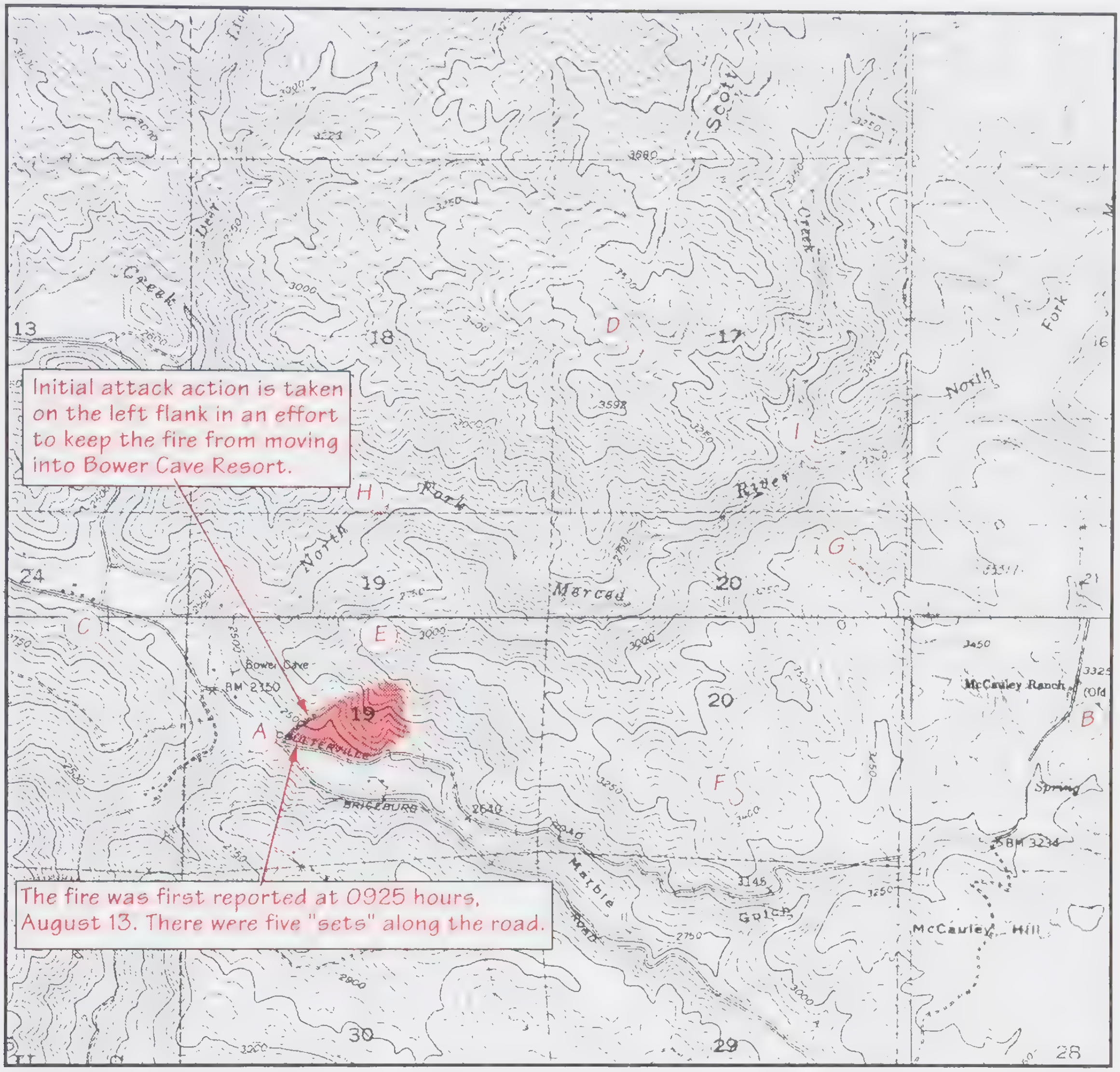
The initial attack is concentrating on the left flank.

The initial attack Incident Commander decides to put all of his effort on the left flank. He starts a direct attack using a hose lay and hand line. The fire behavior is such that it will not allow an attack on the head of the fire. The local volunteer fire company engine is on scene. They are instructed to watch the fire and ensure that it doesn't spot across Coulterville Road.

You arrive at 1020 hours and discuss the situation with the Initial Attack Incident Commander and the chief of the volunteer fire department. The Initial Attack Incident Commander provides you with a map of where he thinks the fire is (Figure 11.52). You all agree that the initial attack has failed and it is going to take several days to control the fire. The fire is now approximately 40 acres and about to cross the ridge.

The IC recons the area.

It is decided to continue all efforts on the left flank in an attempt to keep the fire from crossing the ridge and getting into the Merced River drainage. You assume command and instruct the volunteer chief that he is responsible for keeping the fire above the road (Points A to G). He can burn out the road, but only as much as necessary to keep the fire from jumping it. You establish a two-division fire and assign the Initial Attack IC as Division A, the left flank. The volunteer chief will be Division B.


Scott
Creek
D
17
18
13
North
Fork
River
Merced
H
I
G
19
20
24
C
E
Bowen Cave
BM 2150
A
COULTERVILLE
BRICEBURG
ROAD
Marble
Gulch
F
McCauley Ranch
B
Spring
BM 3234
McCauley Hill
30
29
28
16
21

Initial attack action is taken on the left flank in an effort to keep the fire from moving into Bower Cave Resort.

The fire was first reported at 0925 hours, August 13. There were five "sets" along the road.

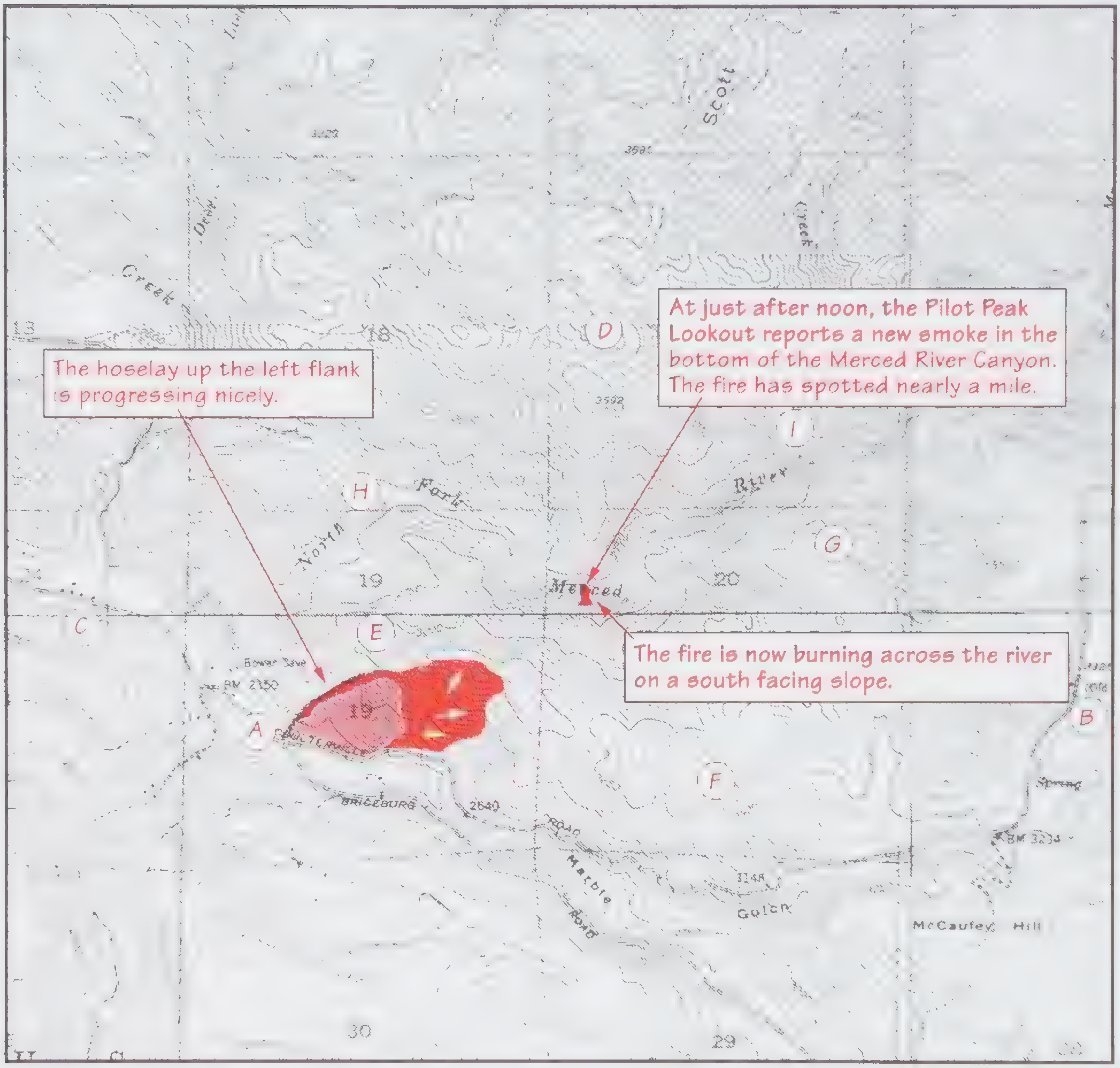
Figure 11.52 The fire's location when you arrive. This particular area hasn't burned in years.

You are fairly familiar with the area, but take the time to scout it out. You proceed up Coulterville Road to the McCauley Ranch. There you meet with the foreman, and he takes you up a jeep road to the ridge top (Point G). You can't get to the fire from Point G without building a road with heavy equipment. You now drive to Point D on Scott Ridge. This is a good road that can be used for access and for burning out if necessary.

By noon the fire has burned about 100 acres.

At about noon you return to the origin (Point A) and meet again with the two Division Supervisors. Division A is continuing to flank the fire, but it is outrunning them. They estimate the fire to be about 100 acres.

At 1216 hours, Pilot Peak Lookout reports a new smoke in the bottom of the Merced River Canyon. The lookout feels that it is a spot fire about ½-mile ahead of the main fire. The situation has now changed; you have fire on both sides of the river (Figure 11.53).


Scott
Creek
Deer
Creek
13
18
D
3592
I
H
North
Fork
River
G
19
Merced
20
C
E
Bower Cave
BM 2350
A
19
B
Spring
F
Briceburg
2640
Road
Marble
Road
3148
Gulch
BM 3234
McCaufey Hill
30
29

The hoselay up the left flank is progressing nicely.

At just after noon, the Pilot Peak Lookout reports a new smoke in the bottom of the Merced River Canyon. The fire has spotted nearly a mile.

The fire is now burning across the river on a south facing slope.

Figure 11.53 The fire has spotted across the river. This presents a whole new problem. You will have to revise your plan.

Solution Required: You know that you will have very limited resources, but you are to develop a strategy and plan to contain the fire using aircraft (if you can get them), bulldozers, handcrews, and a few engine companies. Your plan should include:

- An organizational scheme (number of divisions, groups, etc.).
- Incident objectives.
- General strategies for each segment of line.

The fire has spotted across the Merced River.

Possible Solutions: One suppression strategy is presented for this fire. It involves the establishment of a two-branch fire organization. This actual scenario is based on a real fire that occurred in 1947 on the Stanislaus National Forest. The suppression strategy and final outcome for that fire are presented after our proposed strategy.

Suppression Strategy - A two-branch fire organization is established.

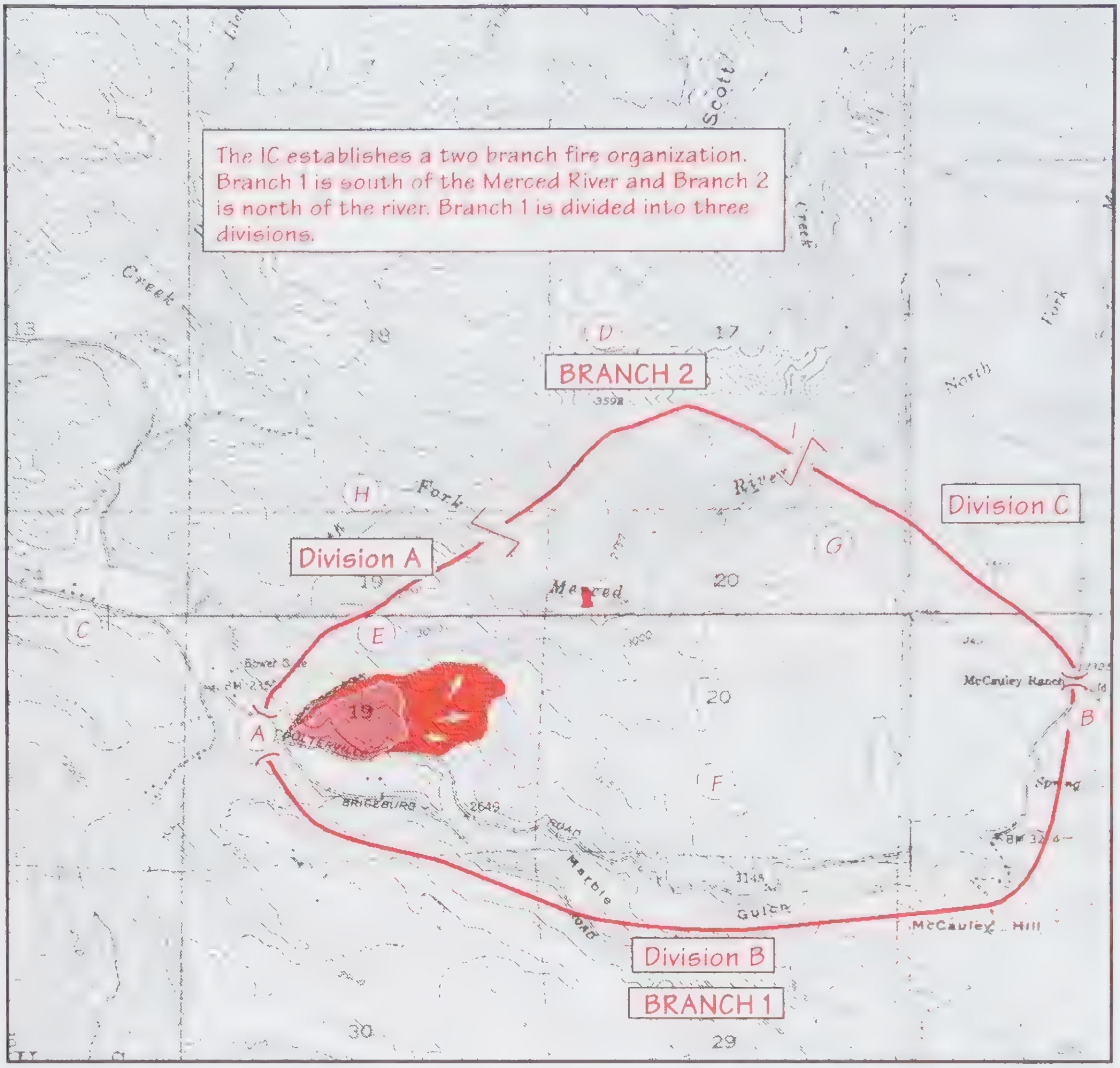
The spot fire north of the Merced River significantly changes the complexity of the fire. The Incident Commander outlines the incident objectives. They are:

- Hold the fire north of Coulterville Road (Points A to B).
- Limit the fire spread north of the Merced River (Points H to G).
- Hold the fire west of a line from the McCauley Ranch to Scott Ridge Road (Points B to D).
- Hold the fire west/southwest of a line from the origin, to Scott Ridge Road (Points A to D).
- Minimize the mechanical disturbance of soils in the Merced River drainage on slopes over 30%.

A two-branch fire is established.

To meet the present and potential organizational needs for this expanding incident, the IC elects to establish a two-branch field organization (Figure 11.54). Branch 1 will be the area south of the Merced River. This branch will be divided into three divisions. Branch 2 will be all the area north of the river. The decision to use a branch north of the river, rather than a fourth division, is based on the expectation that this part of the fire will be expanding and will probably require the establishment of several divisions. The additional divisions would quickly overload an Operations Section Chief. By calling for a Branch Director, you can

Branch 1, the southern branch, will be divided into three divisions.



The IC establishes a two branch fire organization. Branch 1 is south of the Merced River and Branch 2 is north of the river. Branch 1 is divided into three divisions.

Scott
Creek
Creek
13
18
D
17
BRANCH 2
3592
North
Fork
H
Fork
River
Division C
Division A
G
19
Merced
20
C
E
Bower Cave
A
19
COULTERVILLE
BRICEBURG
2649
ROAD
Marble
ROAD
F
20
B
McCauley Ranch
Spring
3148
Gulch
McCauley Hill
Division B
BRANCH 1
30
29

Figure 11.54 A two-branch organization is established. Branch 1 will be all the area south of the Merced River. Branch 2 will be the area north of the river. Branch 1 will be divided into three divisions.

expect to get a more highly qualified and experienced person, one suited for the complexities of this rough section of line.

Division A will continue with their direct attack.

The suppression strategies for the fire will be as follows:

- Division A will continue to use a direct attack until they reach the crest of the ridge at Point E. They can then elect to go indirect, if that is best, being sure to coordinate the line placement with Branch 2.
- Division B will use Coulterville Road as its line. They are to ensure that the fire does not cross the road. It will be fired once all of the other lines on Branch 1 are secured.

- Division C is to construct indirect fireline from McCauley Ranch (Point B) northwest to a point above the river (near Point G). They are to coordinate where they drop off the ridge to the river with Branch 2. This line will be fired from the ridgeline in both directions. The firing will be conducted at night.
- Branch 2 is given two options. They should attempt to keep the fire as small as possible using aircraft and a direct attack from the river, or they can develop an indirect attack, constructing fireline on the ridgeline and firing it out when completed. The placement of fireline from the ridges into the river bottom are to be coordinated with Divisions A and C of Branch 1.
- Fireline with more than a 30% slope in the Merced River drainage will be constructed by handcrews rather than by bulldozers.

Bulldozers or handcrews will be used to construct indirect line.

If Branch 2 elects to go indirect and work from the ridges, a plan like the one outlined in Figure 11.55 could be used. That plan moves most of the line construction to the ridges and along existing roads, utilizing bulldozers to construct the fireline. On the steeper slopes, handcrews are used to construct the line. Engine companies and handcrews are used to fire the line once it has been constructed.

Branch 2, the area north of the river, can take either a direct attack or an indirect attack.

This organizational scheme is just one of many that are possible. The key is to attempt to think beyond the fire as it exists now, to what it will be when everyone arrives and you are actually fighting fire. Keep ahead of the fire and the old "curve." If you fall behind, you will only catch up when the fire allows you to. The following is a discussion of the actual fire on which these preceding scenarios were based.

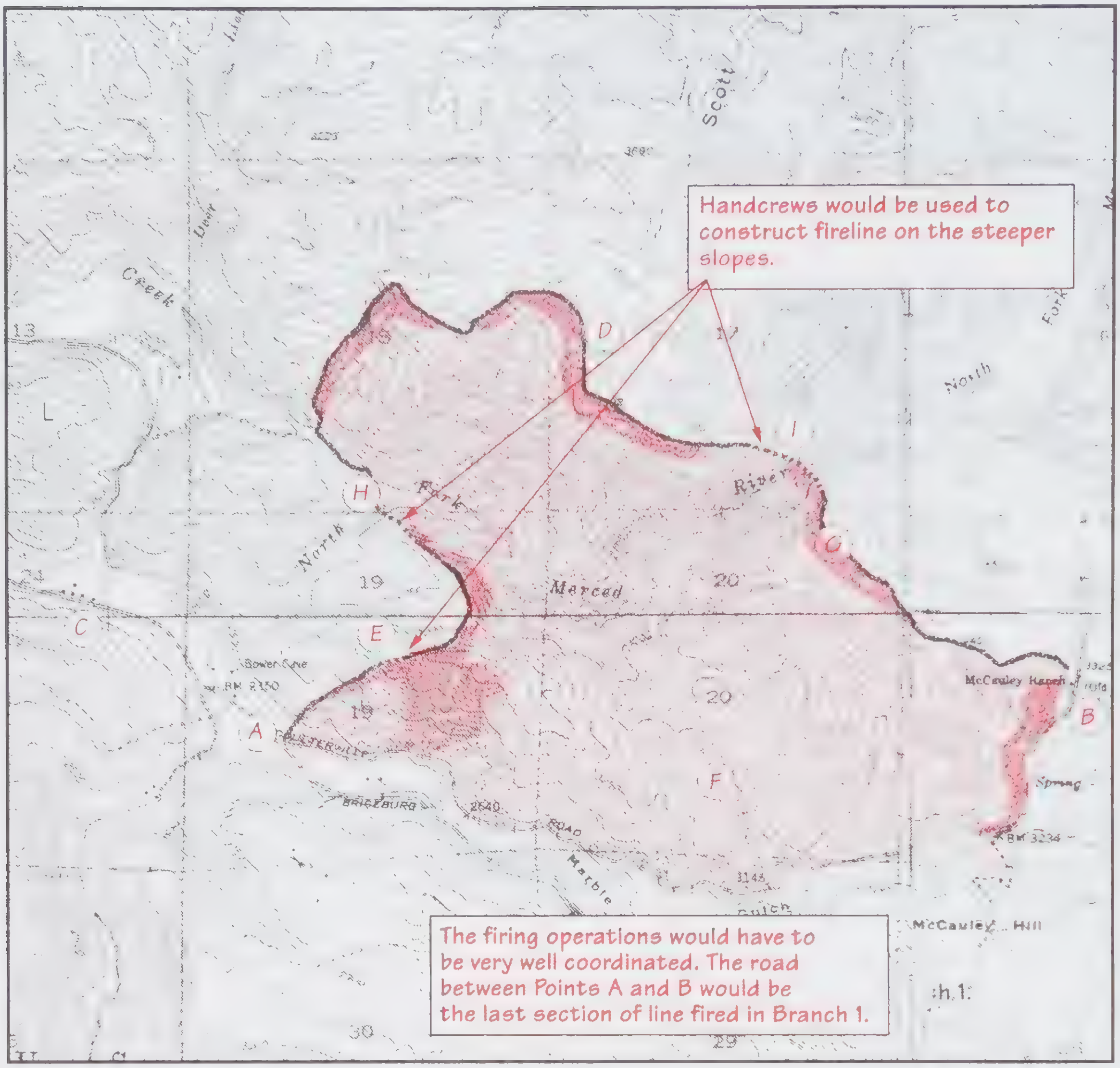
You must attempt to stay ahead of the "curve."

Bower Cave Fire

The Bower Fire started on August 12, 1947, in the Stanislaus National Forest from a series of arson sets. It was contained the next day at just over 1,000 acres. The following is an account of how the fire was fought.

The real fire burned in 1947.

The fire boss developed a plan that required a total of six bulldozers, eight handcrews, and four engine companies on an immediate-need basis. He also requested four additional


Scott
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River
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Merced
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C
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Bower Cave
BM 2150
A
19
20
McCauley Ranch
B
F
Spring
BM 3234
BRICEBURG
2640
ROAD
Marble
3143
Gulch
McCauley Hill
30
29

Handcrews would be used to construct fireline on the steeper slopes.

The firing operations would have to be very well coordinated. The road between Points A and B would be the last section of line fired in Branch 1.

Figure 11.55 If indirect line is planned for most of the area, the fire may burn in a pattern like the one shown on the map. This is about 1,200 acres, contained using indirect line construction and extensive firing out operations. Most of the burning will be done at night.

handcrews, four portable pumps, relief bulldozer operators, and three engines for the day shift and mop-up the following day. The forest dispatcher told the fire boss that the immediate need resources would be on scene by 1800 hours. ETA's for the day shift resources would be provided later.

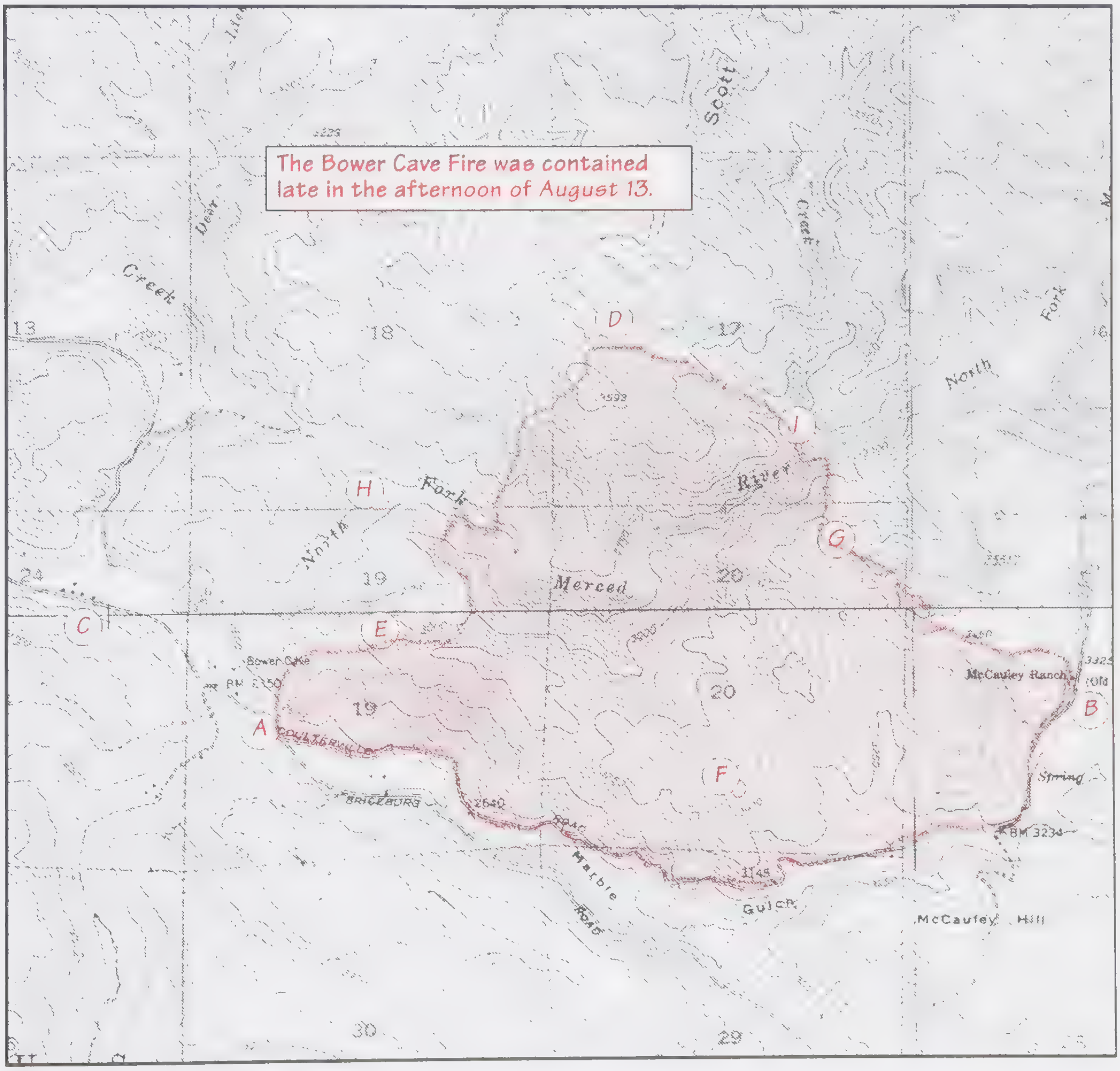
Most of the line was indirect, constructed by a "new tool" in those days, the bulldozer.

The plan was fought by:

- Using handcrews to construct handline from Point A to Point E on the ridge, then dropping off to the river to Point H. When this line was in place it was fired.

- Using two bulldozers to construct fireline from McCauley Ranch (Point B) to the ridge top at Point G and then down the ridge toward the river. When the terrain became too steep, a handcrew was used to complete the line. This line was fired after dark, when the winds were down-canyon.
- Four bulldozers were moved up Scott Ridge Road to Point D. They began construction of fireline down two spur ridges after dark. When the terrain became too steep, handcrews were used. This line was fired before morning.
- Coulterville Road was fired with the use of one handcrew and several engines as soon as the other lines were in.

The fire was contained by 1800 hours the second day.


Scott
Deer
Creek
Creek
13
18
D
17
Fork
North
I
H
Fork
North
River
G
24
19
Merced
20
C
E
Bower Cave
BM 2350
19
20
McCauley Ranch
Old
A
B
COULTERVILLE
F
Spring
BRICEBURG
2640
ROAD
Marble
ROAD
BM 3234
3145
Gulch
McCauley Hill
30
29

The Bower Cave Fire was contained late in the afternoon of August 13.

Figure 11.56 The Bower Cave Fire was contained at about 1,000 acres, August 13, 1947.

The fire was contained at just over 1,000 acres, on August 13, 1947. This fire scenario was presented in the USDA Forest Service Fire Control Notes, Vol. 10, No. 2, dated April, 1949 in a discussion of "new firefighting tools in use," namely, the bulldozer. (Figure 11.56).

Appendix 1

Environmental Protection and Historical Preservation

For years, wildland firefighters didn't give too much consideration to the environment or to preserving our historical heritage. The damage the fire was doing to the land was considered much worse than any damage done by firefighters. Now there is clear evidence that the environment is truly being damaged by our efforts.

Minimize the damage to the environment of fire suppression efforts.

As a fire officer you have to concern yourself with how to reduce the environmental impact of both fire and fire suppression efforts. This chapter will provide an overview of some of the laws and regulations that impact firefighters during a wildland fire.

Federal Legislation

There are several pieces of federal legislation that regulate how you may fight fire within your own jurisdiction and on federal lands. Some of them have been in place for years; others are relatively new and still evolving. It is your responsibility as a fire officer to know of these laws and understand the restrictions they place on you.

Be aware of the laws and regulations which restrict your firefighting activities.

Know the location of historic sites, and attempt to preserve them.

Antiquities Act of 1906 **-** This law is designed to protect our nation's history. It provides that "any person who shall appropriate, excavate, injure, or destroy any historic or prehistoric ruin or monument, or any object of antiquity, situated on lands owned or controlled by the Government of the United States…shall upon being convicted, be fined …or imprisoned…" Even though this law covers federally owned land, most states have enacted similar laws.

What this means to you as a fire officer is that you must know where historic sites are located and construct your firelines well away from them (Figure A2.1).

Violation of laws regarding environmental protection can have serious legal consequences.

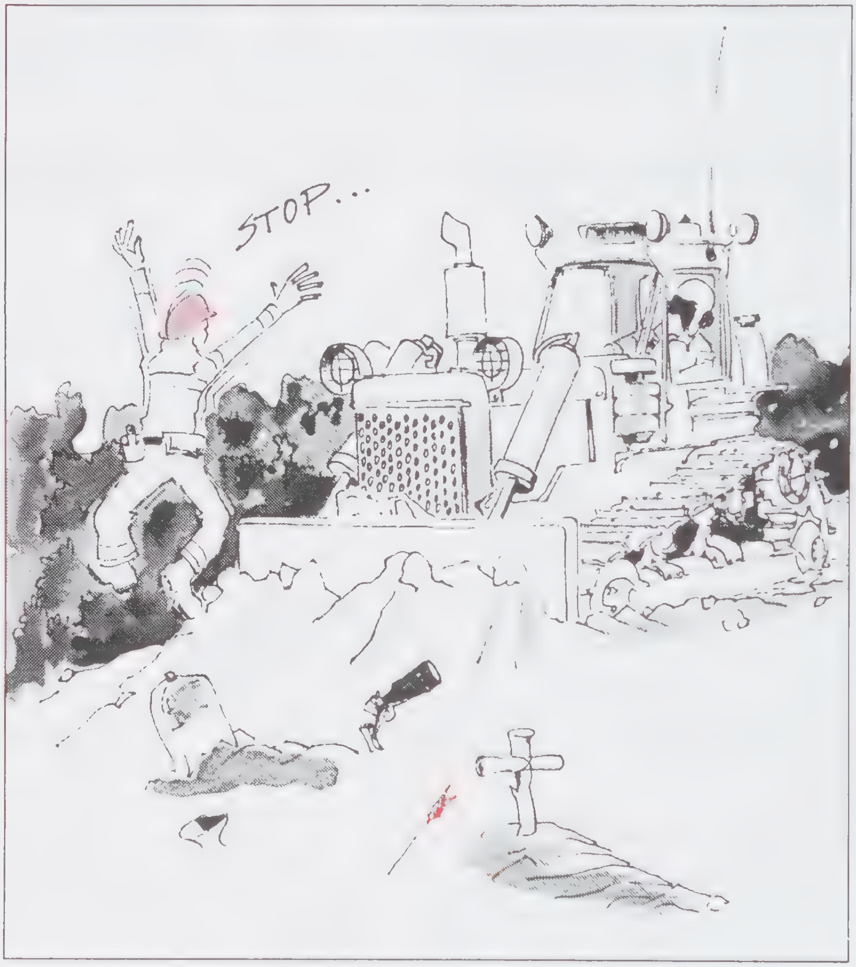


Figure A2.1 Don't go chuggin' your bulldozer down through some prehistoric area; it is a violation of law, and something worse may happen to you!

National Historic Preservation Act of 1966 **-** This Act directs federal agencies to inventory, evaluate, and protect cultural resources under their jurisdiction.

Archaeological Resources Protection Act of 1979 **-** This act is similar to the Antiquities Act of 1906, but it is specific to "archaeological resources" such as pottery, basketry, bottles, weapons, weapon projectiles, tools, structures or portions of structures, pit houses, rock paintings, rock carvings, intaglios, graves, human skeletal materials, etc. The act covers federal or tribal lands, but most states have similar laws protecting other public and private lands.

Archeological sites and resources (artifacts) are protected by law.

Once again, this means that you must stay clear of sites with historic value. Under this law, you can not even pick up or move an arrow head. It is against the law.

As a fire officer you will have to determine where such sites exist. If you happen to stumble across one during your firefight, move out of the area and notify the appropriate authorities.

Clean Air Act **-** The Clean Air Act was first enacted in 1963. This act was established to protect and enhance the quality of the nation's air resources and to protect public health and welfare. Identified in this act are standards and legal requirements that must be met by the Environmental Protection Agency, federal, state and local governmental entities, and private industry and business.

Prescribed burning activities are controlled by EPA regulations.

There has been clean air legislation on the books for years, but the Clean Air Act of 1990 will have the greatest impact on you as a fire officer. Under this legislation, the Environmental Protection Agency and state and local air pollution districts have the power to control your prescribed burning under the act's ambient air quality standards. These standards will become increasingly more restrictive. Some of the key provisions of the act are as follows:

- The EPA is to develop air pollution standards to protect human health.
- States are given primary responsibility for air quality management.

- The states and local air quality districts can establish more stringent regulations.
- All governmental entities are to comply with all air pollution regulations. This includes the payment of established fees.
- Areas with higher pollution (like certain urban area national parks, and wilderness areas can have higher standards.
- It requires agencies to establish control measures for agricultural and silvicultural burning activities.

Small perticulates can have serious health consequences.

The two elements of the Clean Air Act that will most significantly impact prescribed fire programs are the visibility and fine particulate requirements. One of the standards in the act specifically addresses particulates of 10 microns or less (a micron is one-millionth of a meter). This standard is designed to protect that portion of the population which is most susceptible to respirable airborne particulates. A new standard that addresses particulate matter less than 2.5-microns is just on the horizon. Fire is a major source of small particulates and visibility impairment in many states.

Fire produces more small particulates than most other sources.

If you analyze the pollution emissions produced by vehicles, dust, and fire, you can see that fires produce a greater number of smaller particulates than the other sources (Figure A2.2).

PERCENTAGE OF EMISSIONS

Type of Emission	Percentage by Particulate Size			
	less than 2.5 microns	2.5 to 10 microns	less than 10 microns	over 10 microns
Highway Vehicle	21	33	54	46
Fugitive Dust	16	29	45	55
Fire	70	20	90	10

Figure A2.2 Percentage of emissions by source. Note that fire produces a greater number of small particulates than the two other sources.

There is no question that wildland fires and prescribed fires adversely impact air quality. The issue is how to balance the need to use fire to remove the buildup of forest fuels, with the need to keep the air we breathe clean. There will be a time when a national debate will be necessary to decide whether fire can be used to reduce the fuel loading in the Nation's forests or if the desire for clean air will prevail. Right now, clean air is "clearly" more important. The key to the success of this debate is the proper education of the regulators and the public as to the need for proactive prescribed fire programs. If you attack this issue with emotion, you will lose (Figure A2.3).

We need to balance the need for prescribed fire with maintenance of air quality.

Figure A2.3 "The engineer on C-shift says air pollution regulations are to the point that bad breath will be a federal offense under this law. I don't want to get arrested!"

Clean Water Act - In 1972, Congress enacted the Clean Water Act "to restore and maintain the chemical, physical, and biological integrity of the nation's waters." This was a follow-up to the Water Pollution Control Act of 1948. The 1972 legislation established a national goal that all of our waters should be safe and clean.

The 1972 act has a direct impact on how you will be allowed to fight fire. It says that you can't damage or destroy riparian areas (pertaining to the bank of a natural course of water), or pollute waterways with chemicals or soil (from fireline construction). The act doesn't just apply to streams that have water in them. It also applies to the stream beds of intermittent streams.

Know how the Clean Water Act impacts how and where you can fight fire.

Common sense and observance of local forest practice rules will go a long way toward keeping you out of trouble.

Endangered Species Act **-** The Endangered Species Act was signed into law in 1973. It is designed to regulate a wide range of activities affecting plants and animals designated as endangered or threatened. By definition, an "endangered species" is an animal or plant listed by regulations as being in danger of extinction. A "threatened species" is any animal or plant that is likely to become endangered within the foreseeable future. The law specifically prohibits the following activities involving endangered species:

- Importing into or exporting from the United States.
- Taking (includes harassing, harming, pursuing, hunting, shooting, wounding, trapping, killing, capturing, or collecting).
- Possessing, carrying, transporting, or shipping.
- Delivering or receiving.
- Selling or offering for sale.

Violation of the Endangered Species Act is "no laughing matter."

Once an animal or plant has been declared endangered by the US Fish and Wildlife Service, you can't even look at it funny. The penalties are very severe. As a fire officer, you again can't go off and harm directly or change the habitat of an endangered species. You can't fell a snag that may be the future home of an endangered owl, muddy a stream where an endangered salamander lives, or cut fireline through an area where an endangered mouse may live (Figure A2.4).

The most devastating environmental and historic site damage is done with bulldozers.

This cartoon may be funny, but this piece of legislation is very serious. The federal government is serious about the protection of what it feels are endangered species. You may disagree with this, but it is the law and you would be foolish to ignore it. You should know what is endangered in your area and what to watch for.

Environmentally Sensitive Strategies and Tactics

Most of the damage to the environment and historical sites occurs during construction of fireline; the most devastating damage is done with bulldozers.

Fire suppression activities can impact the environment in a number of ways:

- Bulldozer blades and tracks cause damage in and around historic sites by cutting deep into the soil, destroying or displacing artifacts.
- When operated off roads, vehicles can crush cultural material.
- Water pressure can cause erosion to sites, chip away at the integrity of structures, and displace artifacts.
- Handline and helispot construction can damage sites.
- Retardants can cause structural damage and stain artifacts, rocks, and foliage.
- Firefighters can damage the terrain by using the same area over and over for foot traffic or by cutting a line.
- Sites that had been hidden for years may become exposed.
- Felling snags may destroy the nesting sites of endangered species.

Figure A2.4 This fire officer has run into a real foe. This mouse says he is endangered and that "you had better construct that fireline somewhere else!"

The best way to avoid damaging the environment, historically important areas, or artifacts is to stay out of the area. Use natural or other existing barriers as firelines when possible. If possible, construct fireline so that you do not allow the fire to move through sensitive areas.

Firefighting activities damage the environment in a number of ways. Know and avoid them.

If you have to construct fireline, there are things that you should do to reduce the level of damage. Your plan should address watershed rehabilitation efforts, like stream bank stabilization, and the construction of water bars and other erosion and water control measures. Other things which can minimize environmental damage are slash reduction and contour-log structures for erosion control when necessary.

Bibliography

_____, *Advanced Wildland Fire Behavior Calculations S-490*, National Wildfire Coordinating Group, 1993.

_____, *Basic Air Operations S-270*, National Wildfire Coordinating Group, 1991.

_____, *Basic Aviation Safety*, USDI Office of Aircraft Services, 1990.

_____, *CDF Fire Protection Training Handbook 4300 Series*, California Department of Forestry and Fire Protection, 1993.

_____, *Chief Officer*, Fire Protection Publications, 1985.

_____, *Divison/Group Supervisor I-339*, National Wildfire Coordinating Group, 1985.

_____, *Essentials of Firefighting*, Fire Protection Publications, 1983.

_____, *Federal Wildland Fire Management Policy and Program Review*, USDA Forest Service and USDI Bureau of Land Management, 1995.

_____, *Field Operations Guide ICS 420-1*, Incident Command System Publication, 1994.

_____, *Fire Behavior Field Reference Guide*, National Wildfire Coordinating Group, 1992.

_____, *Fire Behavior in the Wildland/Urban Interface*, National Fire Protection Association, 1986.

_____, *Fire Department Company Officer*, Fire Protection Publications, 1989.

_____, *Fire Operations in the Urban Interface S-205*, National Wildfire Coordinating Group, 1991.

_____, *Fire Protection in the Wildland/ Urban Interface: Everyone's Responsibility*, National Wildland/Urban Interface Fire Protection Program.

_____, *Fire Service First Responder*, Fire Protection Publications, 1987.

_____, *Fire Suppression Tactics S-336*, National Wildfire Coordinating Group, 1990.

_____, *Firefighter Training S-130*, National Wildfire Coordinating Group, 1993.

_____, *Firefighters Guide*, National Wildfire Coordinating Group, 1986.

_____, *Fireline Handbook Appendix B - Fire Behavior*, National Wildfire Coordinating Group, 1993.

_____, *Fireline Handbook NWCG Handbook 3*, National Wildfire Coordinating Group, 1989.

_____, *Fireline Supervisor Checklists*, Victoria Conservation and Environment Fire Management Branch, 1992.

_____, *Firing Methods and Procedures S-234*, National Wildfire Coordinating Group, 1991.

_____, *Foam vs Fire - Class A Foam for Wildland Fires*, National Wildfire Coordinating Group, 1992.

_____, *Forest Service Health and Safety Code - Your Guide to Safe Practices*, USDA Forest Service, 1970.

_____, *ICS Forms Manual*, National Wildfire Coordinating Group, 1987.

_____, *Incident Air Operations Reminders*, USDA Forest Service Region 1, 1991.

_____, *Incident Command System National Training Curriculum Series*, National Wildfire Coordinating Group, 1994.

_____, *Incident Command System*, Fire Protection Publications, 1983.

_____, *Incident Commander Multiple Resources Extended Attack S-300*, National Wildfire Coordinating Group, 1986.

_____, *Initial Attack Incident Commander S-200*, National Wildfire Coordinating Group, 1989.

_____, *Intermediate Wildland Fire Behavior S-290*, National Wildfire Coordinating Group, 1994.

_____, *Introduction to Fire Behavior S-190*, National Wildfire Coordinating Group, 1983.

_____, *Introduction to Wildland Fire Behavior Calculations S-390*, National Wildfire Coordinating Group, 1994.

_____, *Introduction to Wildland Fire Suppression for Rural Fire Departments*, National Wildfire Coordinating Group, 1985.

_____, *Land Areas of the National Forest System*, USDA Forest Service, 1995.

_____, *Leadership and Organizational Development S-301*, National Wildfire Coordinating Group, 1996.

_____, *Leadership in the Fire Service*, Fire Protection Publications, 1967.

_____, *Look Up, Look Down, Look Around*, National Wildfire Coordinating Group, 1992.

_____, *Miller's Reach #2 Fire Review, A Report to the Commissioner, Department of Natural Resources*, State of Alaska, 1996.

_____, *Minimum Impact Suppression Tactics*, USDA Forest Service Northern Region, 1993.

_____, *National Fire-Danger Rating System, Users' Guide*, National Wildfire Coordinating Group, 1985.

_____, *Planning for Initial Attack!*, National Wildfire Coordinating Group, 1985.

_____, *Point Fire Accident Investigation*, USDI Bureau of Land Management, 1995.

_____, *Prescribed Fire for Burn Bosses RX-90*, National Wildfire Coordinating Group, 1993.

_____, *Single Resource Boss - Crew S-230*, National Wildfire Coordinating Group, 1990.

_____, *South Canyon Fire Investigation*, USDA Forest Service and USDI Bureau of Land Management, 1994.

_____, *Staging Area Manager J-236*, National Wildfire Coordinating Group, 1996.

_____, *Standards for Survival*, National Wildfire Coordinating Group, 1987.

_____, *Supervisory Concepts and Techniques S-201*, National Wildfire Coordinating Group, 1996.

_____, *The CEO's Disaster Survival Kit*, Federal Emergency Management Agency, 1988.

_____, *The Oakland Tunnel Fire, October 20, 1991*, City of Oakland, 1992.

_____, *The Oakland/Berkeley Hills Fire*, National Fire Protection Association, 1991.

_____, *Tractor Use/Tractor Boss S-213*, National Wildfire Coordinating Group, 1979.

_____, *Training and Equipment - Air Operations, Helicopter Safety*, Los Angeles County Fire Department, 1988.

_____, *Tunnel Wildfire Oakland-Berkeley Hills October 20-23, 1991*, USDC National Oceanic and Atmospheric Administration, 1992.

_____, *Unified Command*, National Wildfire Coordinating Group, 1985.

_____, *Wildland Firefighting Essentials - Fire Control 6*, California Fire Service Training and Education System, 1992.

Anderson, Hal E., *Aids to Determine Fuel Models for Estimating Fire Behavior*, National Wildfire Coordinating Group, 1982.

Andrews, Patricia L. and Rothermel, Richard C., *Charts for Interpreting Wildland Fire Behavior Characteristics*, National Wildfire Coordinating Group, 1982.

Andrews, Patricia L., *BEHAVE: Fire Behavior Prediction and Fuel Modeling System*, USDA Forest Service Intermountain Research Station, 1986.

Auf Der Heide, Erik, *Disaster Response - Principles of Preparation and Coordination*, The C. V. Mosby Company, 1989.

Bennis, Warren and Nanus, Bert, *Leaders, The Strategies for Taking Charge*, Harper and Row Publishers, 1985.

Bishop, Jim, *Structure Triage in Izone Fires*, Fire Chief Magazine, pages 26-29, June 1995.

Braun, Curt C. and Latapie, Buck, *Human Decisionmaking in the Fire Environment*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

Brown, Lee P., *Training Overhead for Suppression Work*, Fire Control Notes, USDA Forest Service, 1939.

Brunacini, Alan V., *Fire Command*, National Fire Protection Association, 1985,

Byram, George M., *Atmospheric Conditions Related to Blowup Fires*, National Wildfire Coordinating Group, 1954.

Campbell, Doug, *The Campbell Prediction System, A Wildland Fire Prediction System and Language*, Doug Campbell, 1991.

Campbell, Doug, *Wildland Fire Specialist*, Doug Campbell, 1994.

Clar, Raymond C. And Chatten, Leonard R., *Principles of Forest Fire Management*, California Division of Forestry, 1975.

Clayton, B., Day, D. And McFadden, J. M., *Wildland Firefighting*, California Department of Forestry and Fire Protection, 1986.

Coleman, Ronny J., *Urban-Wildland Fire Problems - The Policy Context*, California State Fire Marshal's Office, 1994.

Countryman, Clive M., *The Fire Environment Concept*, National Wildfire Coordinating Group, 1972.

Covey, Stephen R., *The 7 Habits of Highly Effective People, Powerful Lessons in Personal Change*, Simon & Schuster, 1989.

Crosby, Bill, *Our Wild Fire*, Sunset Magazine, pages 64-73, June 1992.

Davis, Kenneth P., *Forest Fire Control and Use*, McGraw-Hill Book Company, 1959.

Drucker, Peter F., *The Effective Executive*, Harper and Row Publishers, 1966.

Gaylor, Harry P., *Wildfires, Prevention and Control*, Robert J. Brady Company, 1974.

Grace, H., Asplund, R, Ely, J, Intorf, P., and Droege, R. F., *Fireman's Guide*, USDA Forest Service California Region, 1956.

Haines, Donald A., *A Lower Atmospheric Severity Index for Wildland Fires*, National Weather Digest 13(2): 23-27, 1988.

Harvey, Jerry B., *The Abilene Paradox and Other Meditations on Management*, Lexington Books, 1988.

Jukkala, Art, and Putnam, Ted, *Forest Fire Shelters Save Lives*, USDA Forest Service Missoula Technology and Development Center, 1986.

Klein, J. O., Calderwood, R., Zsamobok, C. E., *Decision Making in Action: Models and Methods*, Ablex Publishing, 1993,

Kouzes, James M., and Posner, Barry Z., *Credibility; How Leaders Gain and Lose It, Why People Demand It*, Jossey-Bass, 1993.

Lee, Kevin, *A Potential Life Saver-Training with a Practice Fire Shelter*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

Linkewich, Alexander, *Air Attack on Forest Fires - History and Techniques*, D. W. Friesen and Sons, 1972.

Mangan, Richard, J., *Personal Protective Equipment in Wildland Entrapments*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

Moore, William R., *Training in the Ten Standard Fire Fighting Orders*, Fire Control Notes, USDA Forest Service, 1959.

Perry, Donald G., *Managing a Wildland Fire - A Practical Perspective*, Fire Publications, 1989.

Perry, Donald G., *Wildland Firefighting - Fire Behavior, Tactics and Command*, Fire Publications, 1990.

Peters, T. J. and Waterman, Jr., R. H., *In Search of Excellence, Lessons from America's Best-Run Companies*, Warner Books, 1984.

Potter, Brian E., *Regional Analysis of Haines' LASI*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

Powell, Pam, *Managing People; Fire Service Personnel Strategies*, National Fire Protection Association, 1984.

Primozic, K., Primozic, E., and Loben, J., *Strategic Choices, Supremacy, Survival, or Sayonara*, McGraw-Hill, 1991.

Putnam, Ted, *Analysis of Escape Efforts and Personnel Protective Equipment on the South Canyon Fire*, Wildfire Magazine, page 42 to 47, September 1995.

Putnam, Ted, *Findings from the Wildland Firefighters Human Factors Workshop*, USDA Forest Service Missoula Technology and Development Center, 1995.

Putnam, Ted, *The Collapse of Decisionmaking and Organizational Structure on Storm King Mountain*, USDA Forest Service Missoula Technology and Development Center, 1995.

Putnam, Ted, *Your Fire Shelter, Beyond the Basics*, USDA Forest Service Missoula Technology and Development Center, 1996.

Pyne, Stephen J., *World Fire, The Culture of Fire on Earth*, Henry Holt and Company, 1995.

Richman, Harold, *Engine Company Fireground Operations*, National Fire Protection Association, 1986.

Roberts, Wes, *Leadership Secrets of Attilla the Hun*, Warner Books, 1987.

Rothermel, Richard C. and Mutch, Robert W., *Behavior of the Life-Threatening Butte Fire: August 27-29, 1985*, USDA Forest Service Intermountain Research Station, 1994.

Rothermel, Richard C. and Rinehart, George C., *Field Procedures for Verification and Adjustment of Fire Behavior Predictions*, National Wildfire Coordinating Group, 1983.

Rothermel, Richard, C., *Mann Gulch Fire: A Race That Couldn't Be Won*, USDA Forest Service Intermountain Research Station, 1993.

Schroeder, Mark J. and Buck, Charles C., *Fire Weather*, USDA Forest Service, 1970.

Sharkey, Brian J., *Fit to Work?,* USDA Forest Service Missoula Equipment Development Center, 1985.

Snow, S. B., Hopkins, H., Deering, R. L., Gowen, G. M., and Gustafson, C. A., *Fire Control Handbook, Control and Dispatching Actions Applicable to Large Fires*, USDA Forest Service Region 5, 1940.

Spitzbart, Abraham and Bardell, Ross H., *College Algebra and Plane Trigonometry*, Addison-Wesley Publishing, 1955.

Steen, Harold K., *The Origins of the National Forests*, Forest History Society, 1992.

Teie, William C., *Firefighter's Handbook on Wildland Firefighting, Strategy, Tactics and Safety*, Deer Valley Press, 1994.

Weatherford, Brian, *Fire Control Notes Series*, California Department of Forestry and Fire Protection, 1989.

Williams, Jerry, *Firefighter Safety in Changing Forest Ecosystems*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

Wilson, Carl C. and Sorensen, James C., *Common Denominators of Fire Behavior on Tragedy and Near-Miss Forest Fires*, National Wildfire Coordinating Group, 1992.

Yellstrom, Stephen J., *Establishing an Effective Safety and Health Program for Firefighters*, Fire Control Notes Volume 55, Number 3, USDA Forest Service, 1995.

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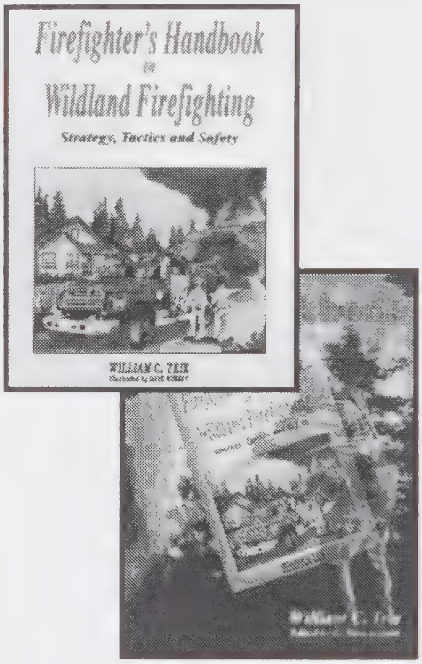
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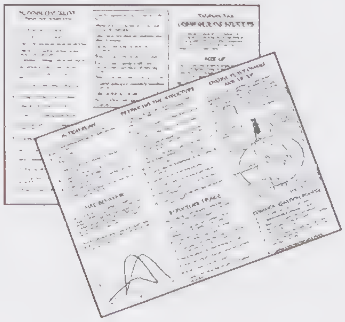

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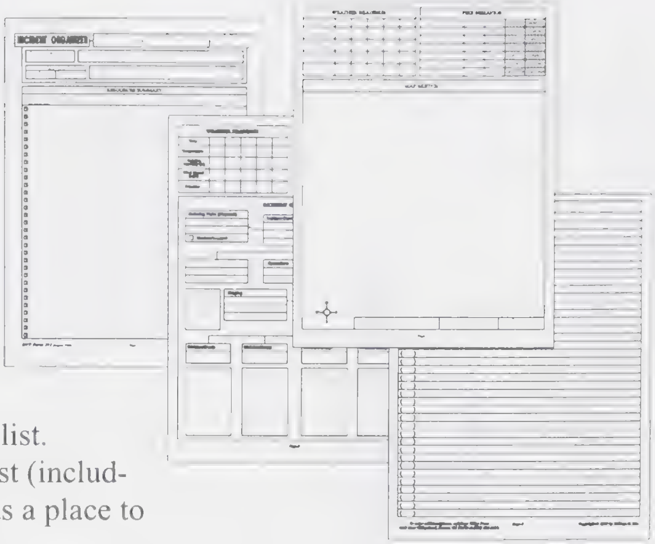

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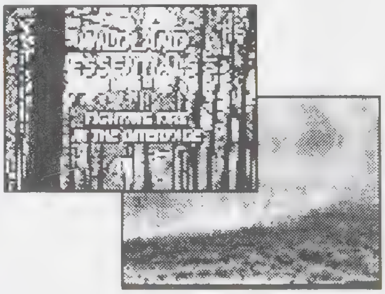

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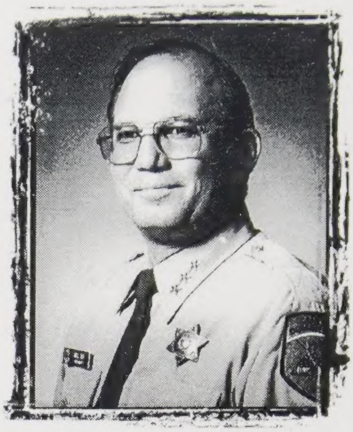

William C. Teie retired from the California Department of Forestry and Fire Protection (CDF) after a successful 34-year career. He worked up through the ranks from seasonal firefighter to Deputy Director for Fire Protection. In this position, he was responsible for all of the fire protection programs within CDF.

Chief Teie was very active in the California fire service. He was on several statewide boards and committees and in 1986, was elected President of the California Fire Chiefs Association.

He is the author of the ***Firefighter's Handbook on Wildland Firefighting*** and has developed several other training and operational aids for the firefighter. He provides consulting services mainly in the area of military and space technology conversion and application to fire service use.

About the Artist

Dave Hubert retired after 30 years of service with the Orange County (CA) Fire Authority and CDF. During his career, Captain Hubert served as an engine company captain, truck company captain, in fire prevention and as a training officer. For some time, he served as the wildland fire defense coordinator specializing in community fire defense programs.

Captain Hubert was very active with the California State Firefighters Association and the Orange County Firemen's Association.

He is dedicated to his family, enjoys fire service artwork and working on his 1902 horse-drawn steam fire engine, which was featured in the 1997 Tournament of Roses Parade.

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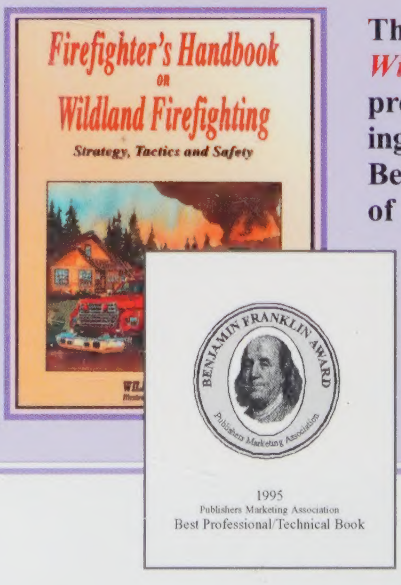
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